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United States Patent [19]

Braun et al.

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[54] **COMPUTER-BASED SIMULATION EXAMINATION OF ARCHITECTURAL PRACTICE**

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[21] Appl. No.: **08/811,890**

[22] Filed: **Mar. 5, 1997**

[51] **Int. Cl.**[7] **G09B 7/00**

[52] **U.S. Cl.** **434/323**; 434/327; 434/350; 345/133

[58] **Field of Search** ..... 434/118, 219, 434/169, 185, 307 R, 308, 322, 323, 234, 350, 362, 327; 345/133, 348, 349; 706/927, 915; 707/102

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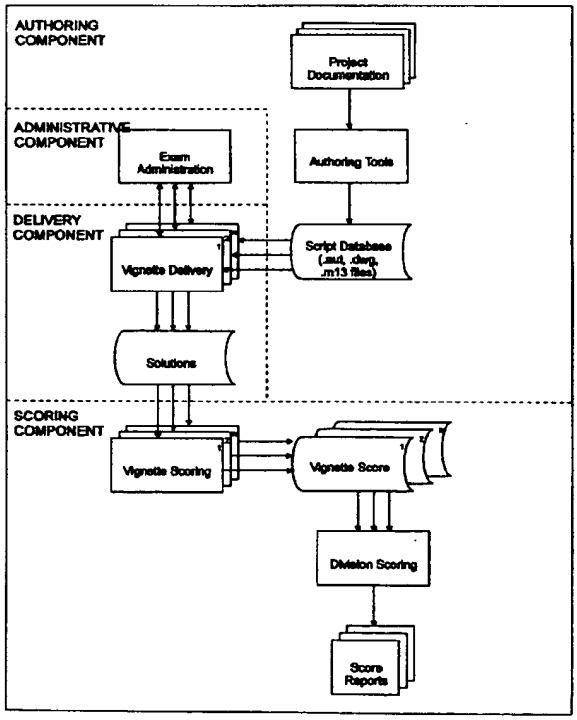
[57] **ABSTRACT**

The present invention relates to computer-based technology in assessment particularly for the licensing and certification of professionals such as architects and engineers. For assessment of architects, the system includes tools and methods for item creation, computer programs for computerized item presentation, and programs for automatically scoring test responses by computer.

53 Claims, 70 Drawing Sheets



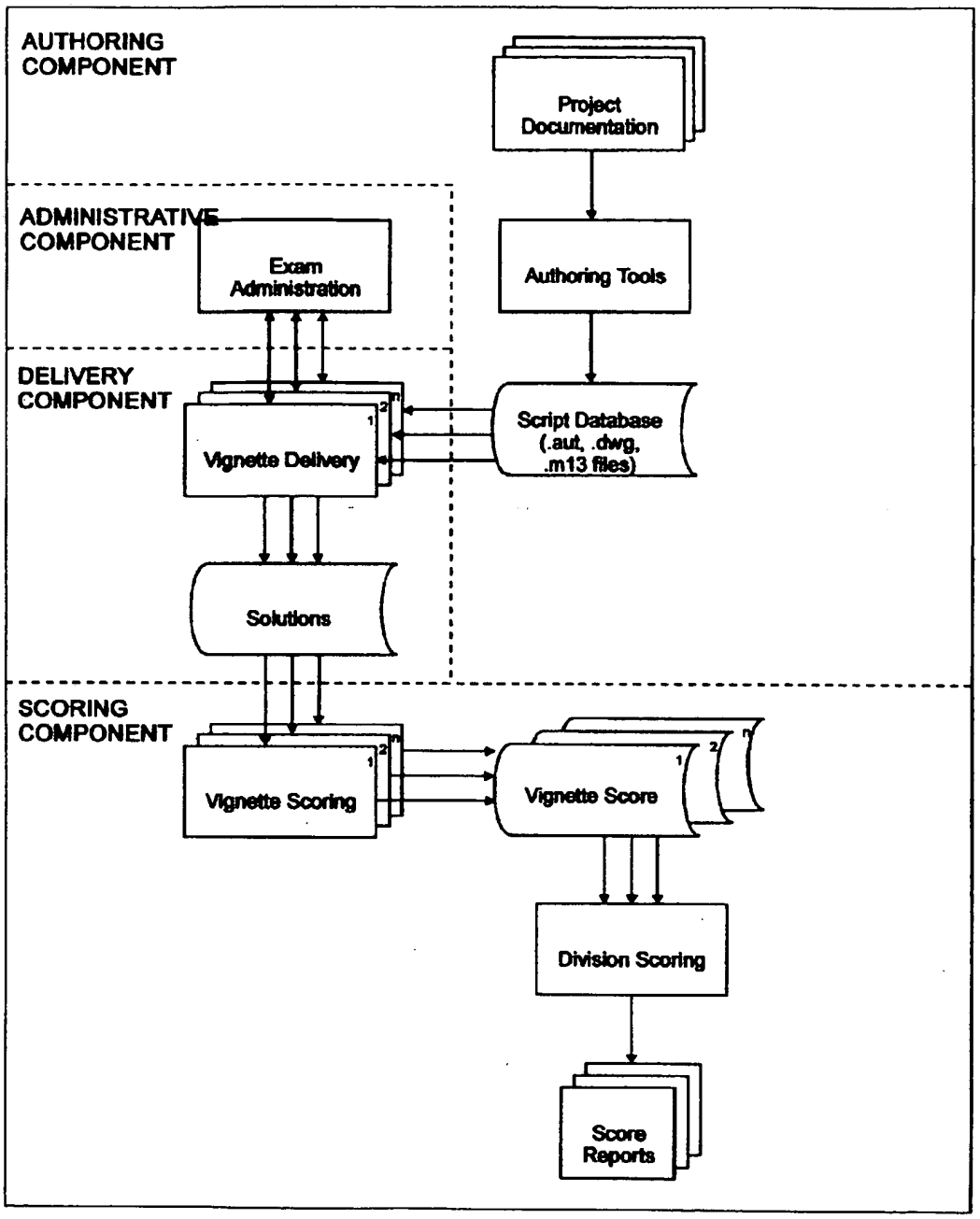

AUTHORING COMPONENT
Project Documentation
ADMINISTRATIVE COMPONENT
Exam Administration
Authoring Tools
DELIVERY COMPONENT
Vignette Delivery
Script Database (.aut, .dwg, .m13 files)
Solutions
SCORING COMPONENT
Vignette Scoring
Vignette Score
Division Scoring
Score Reports

FIG. 1

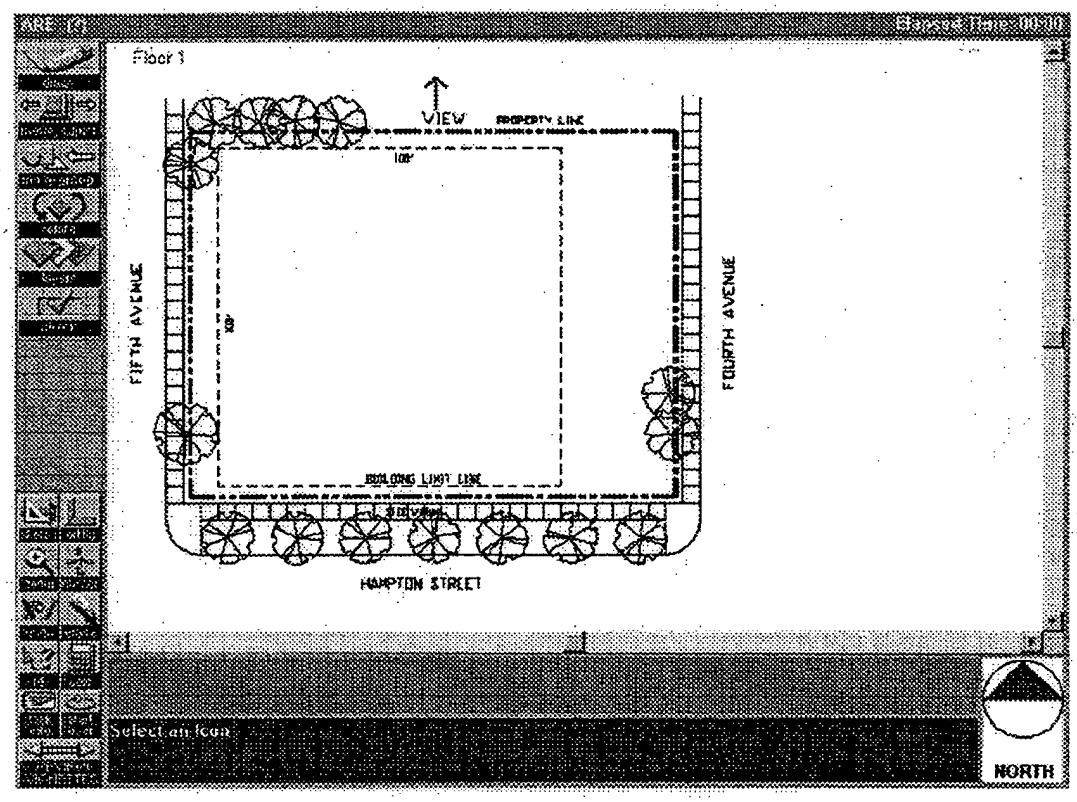

Floor 1
VIEW
PROPERTY LINE
100'
80'
FIFTH AVENUE
FOURTH AVENUE
BUILDING LINE LINE
HAMPTON STREET
Select an Icon
NORTH

FIG. 2

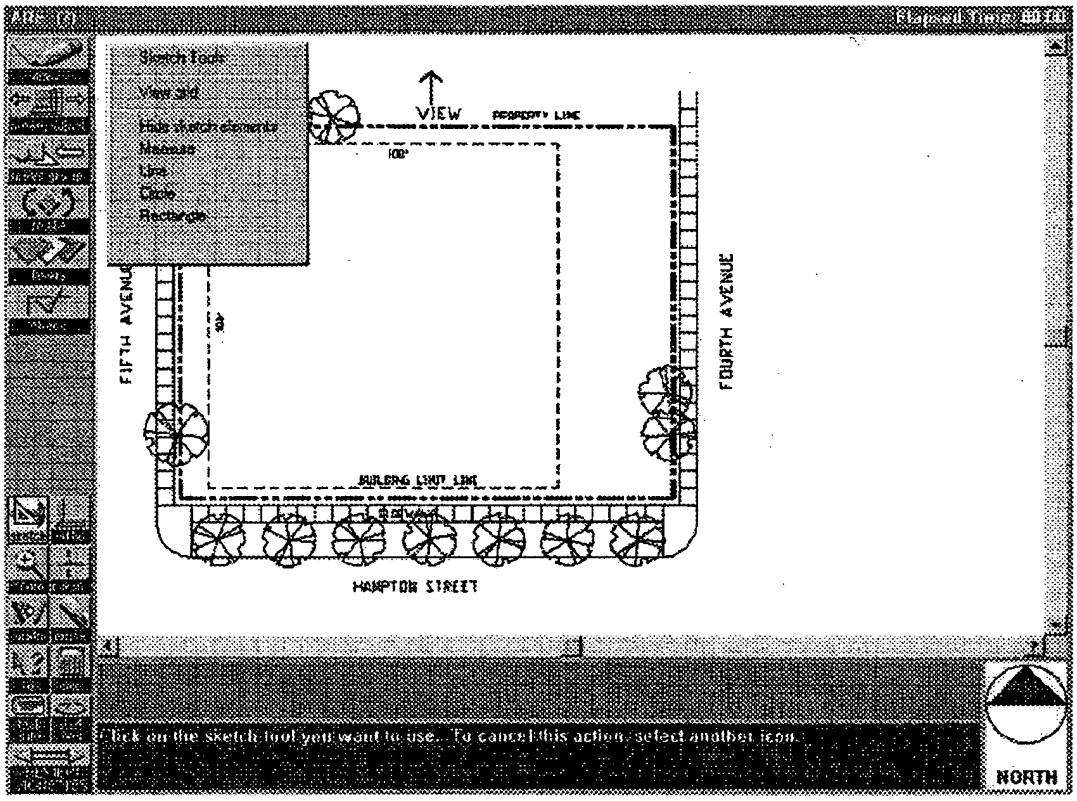

Sketch Tools
View grid
Hide sketch elements
Measure
Line
Circle
Rectangle
VIEW
PROPERTY LINE
100'
FIFTH AVENUE
FOURTH AVENUE
BUILDING LIMIT LINE
HAMPTON STREET
Click on the sketch tool you want to use. To cancel this action, select another icon.
NORTH

FIG. 3

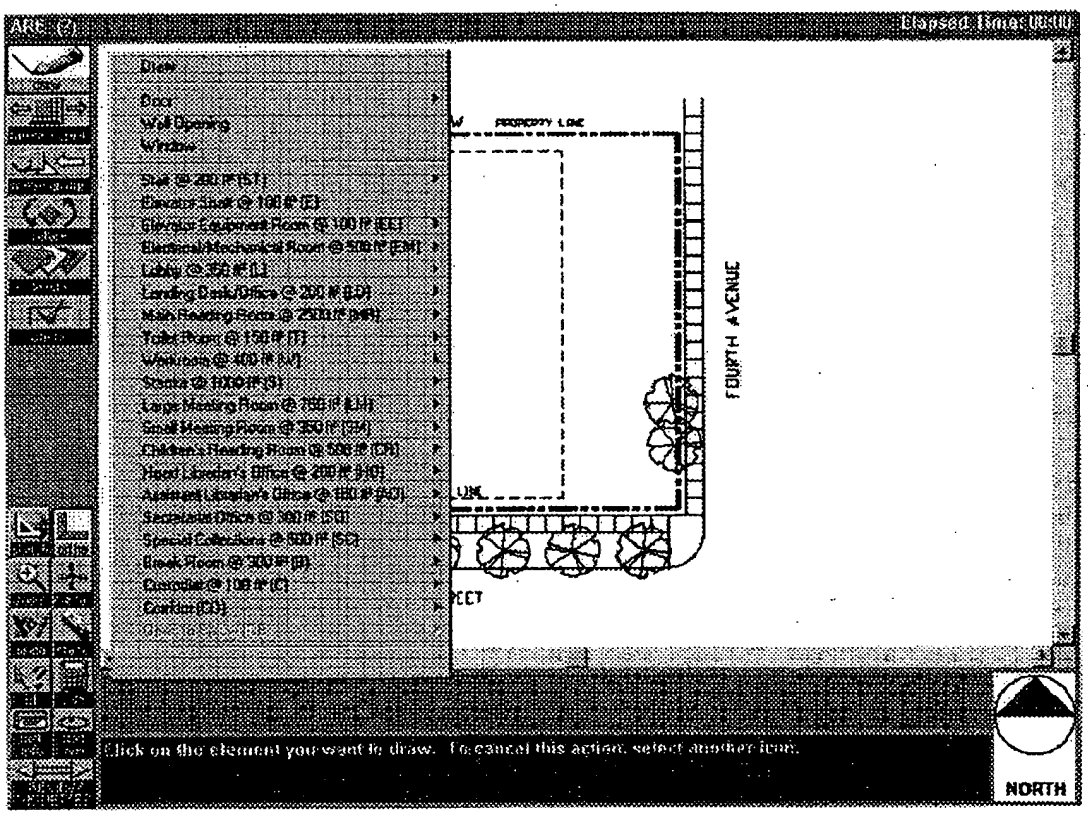


FIG. 4

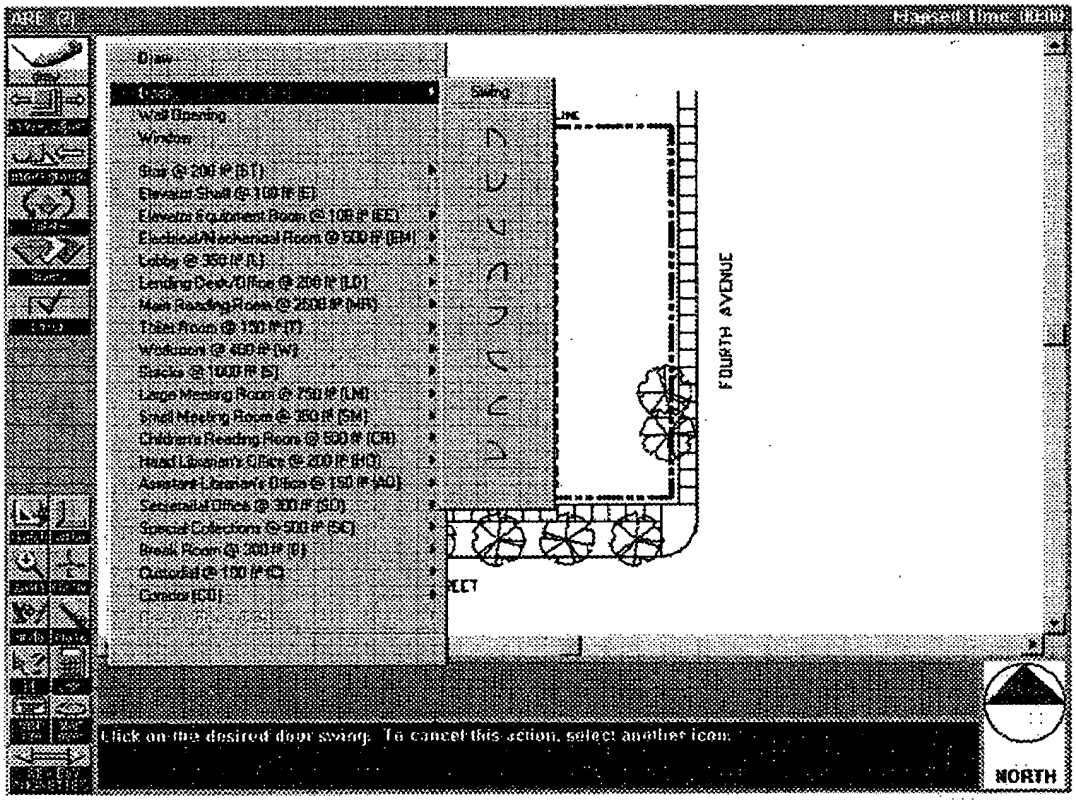

Draw
Wall Opening
Window
Swing
FOURTH AVENUE
Click on the desired door swing. To cancel this action, select another icon.
NORTH

FIG. 5

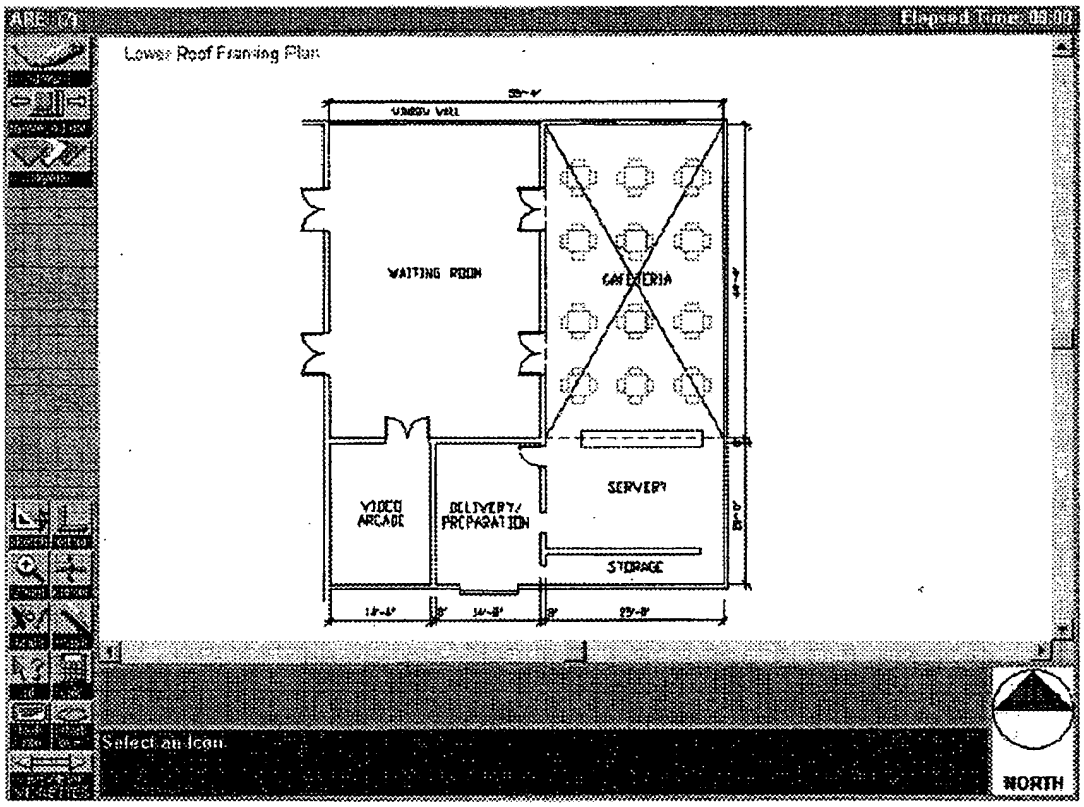

Lower Roof Framing Plan
WAITING ROOM
CAFETERIA
VIDEO ARCADE
DELIVERY/ PREPARATION
SERVERY
STORAGE
Select an Icon
NORTH

FIG. 6

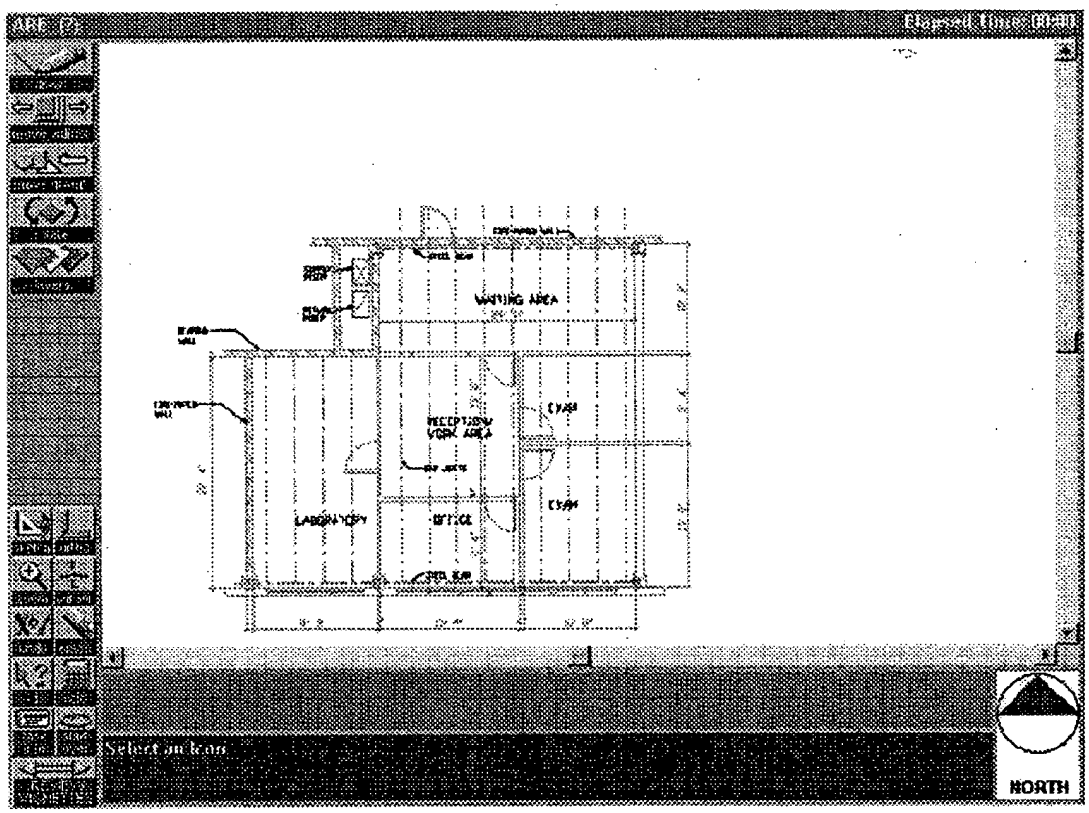

Elapsed Time: 0:01
WAITING AREA
RECEPTION/ WORK AREA
EXAM
EXAM
LABORATORY
OFFICE
Select an item
NORTH

FIG. 7

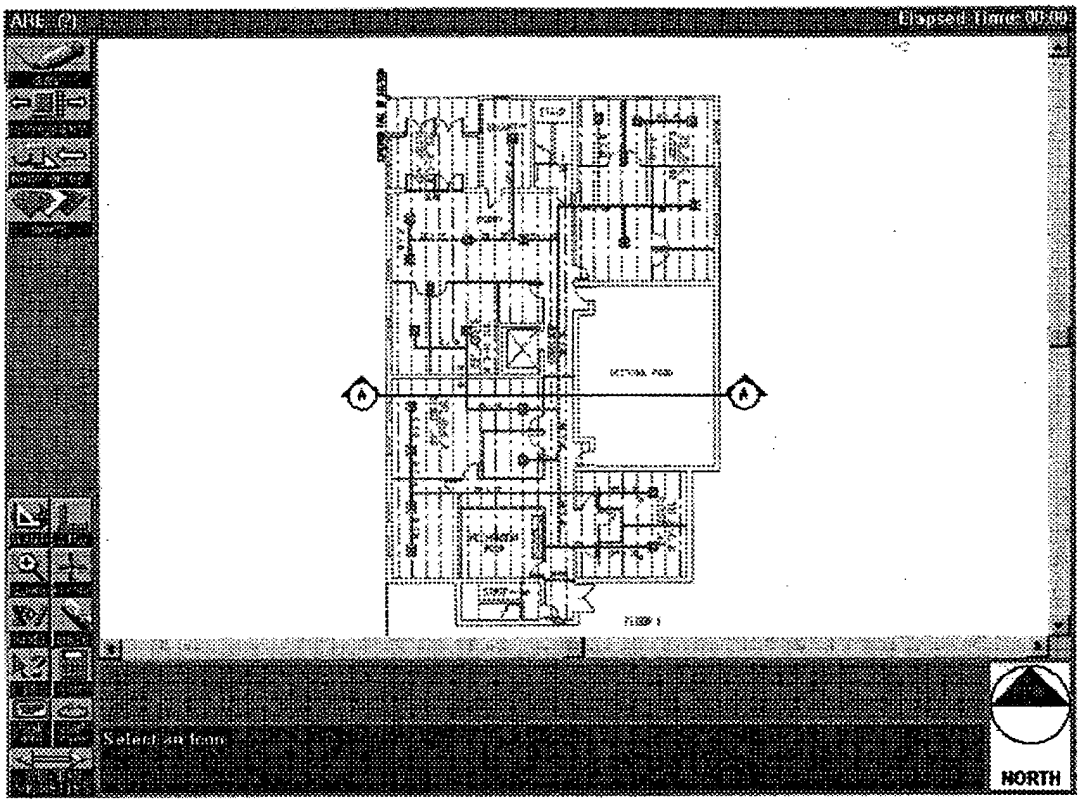


FIG. 8

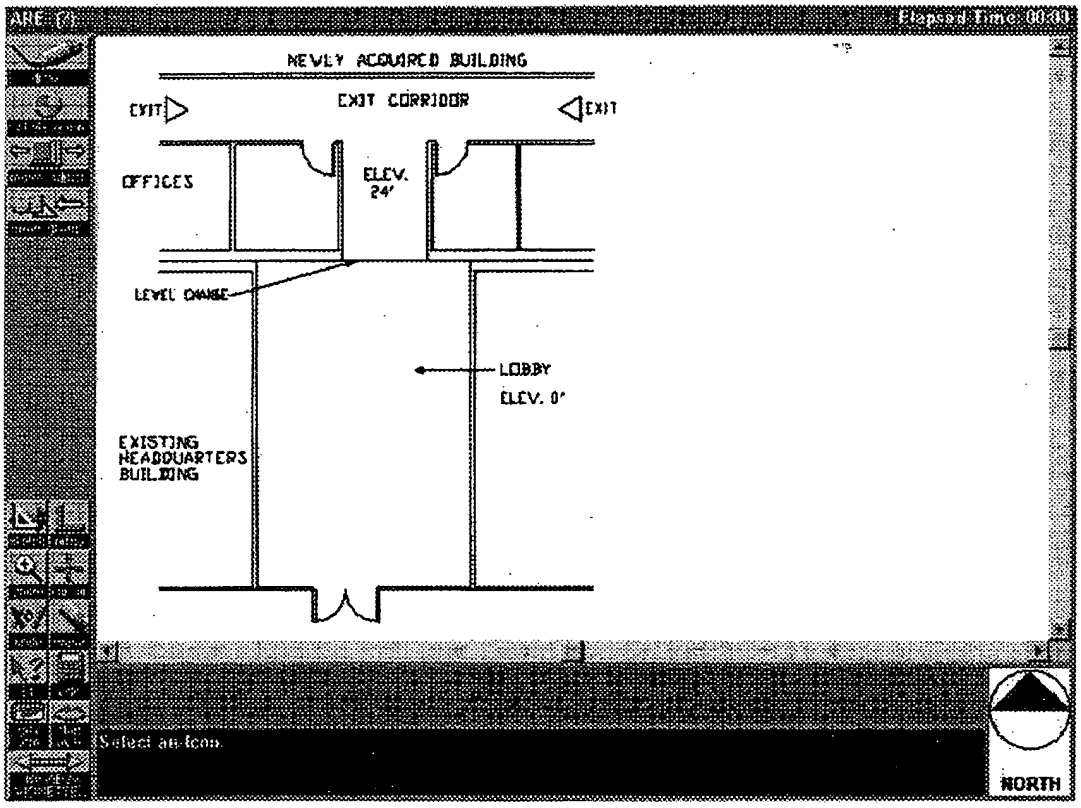

NEWLY ACQUIRED BUILDING
EXIT CORRIDOR
EXIT
EXIT
OFFICES
ELEV.
24'
LEVEL CHANGE
LOBBY
ELEV. 0'
EXISTING
HEADQUARTERS
BUILDING
NORTH

FIG. 9

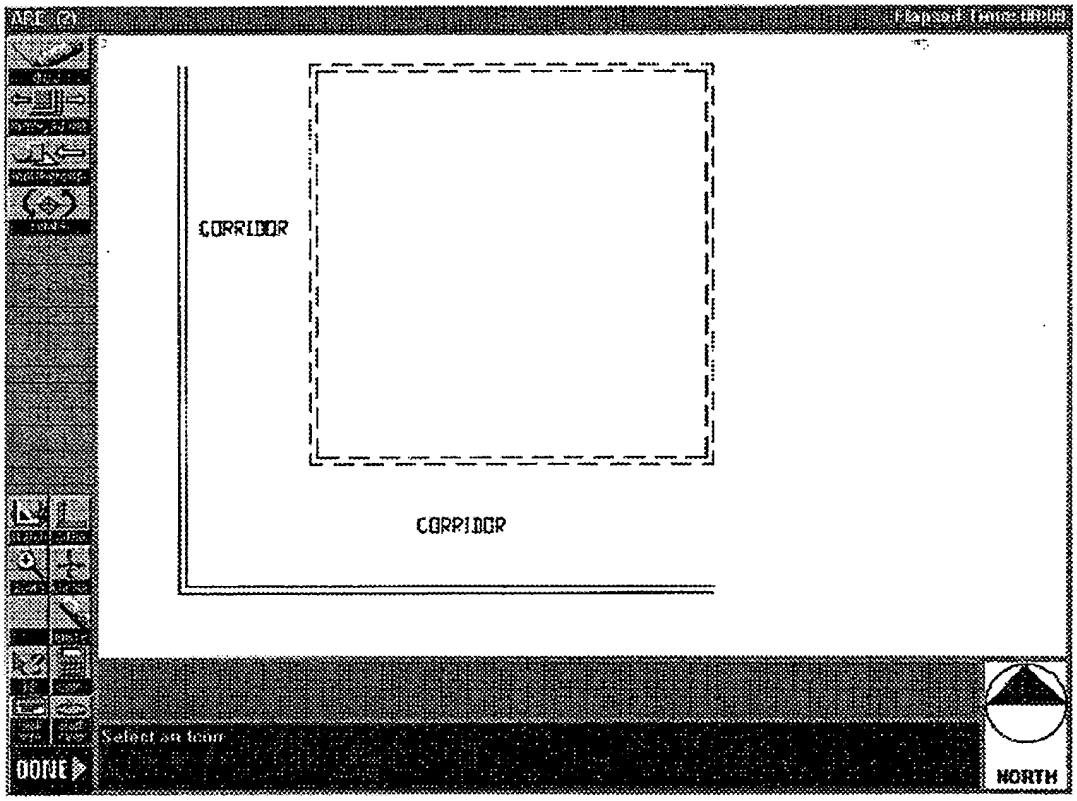


FIG. 10

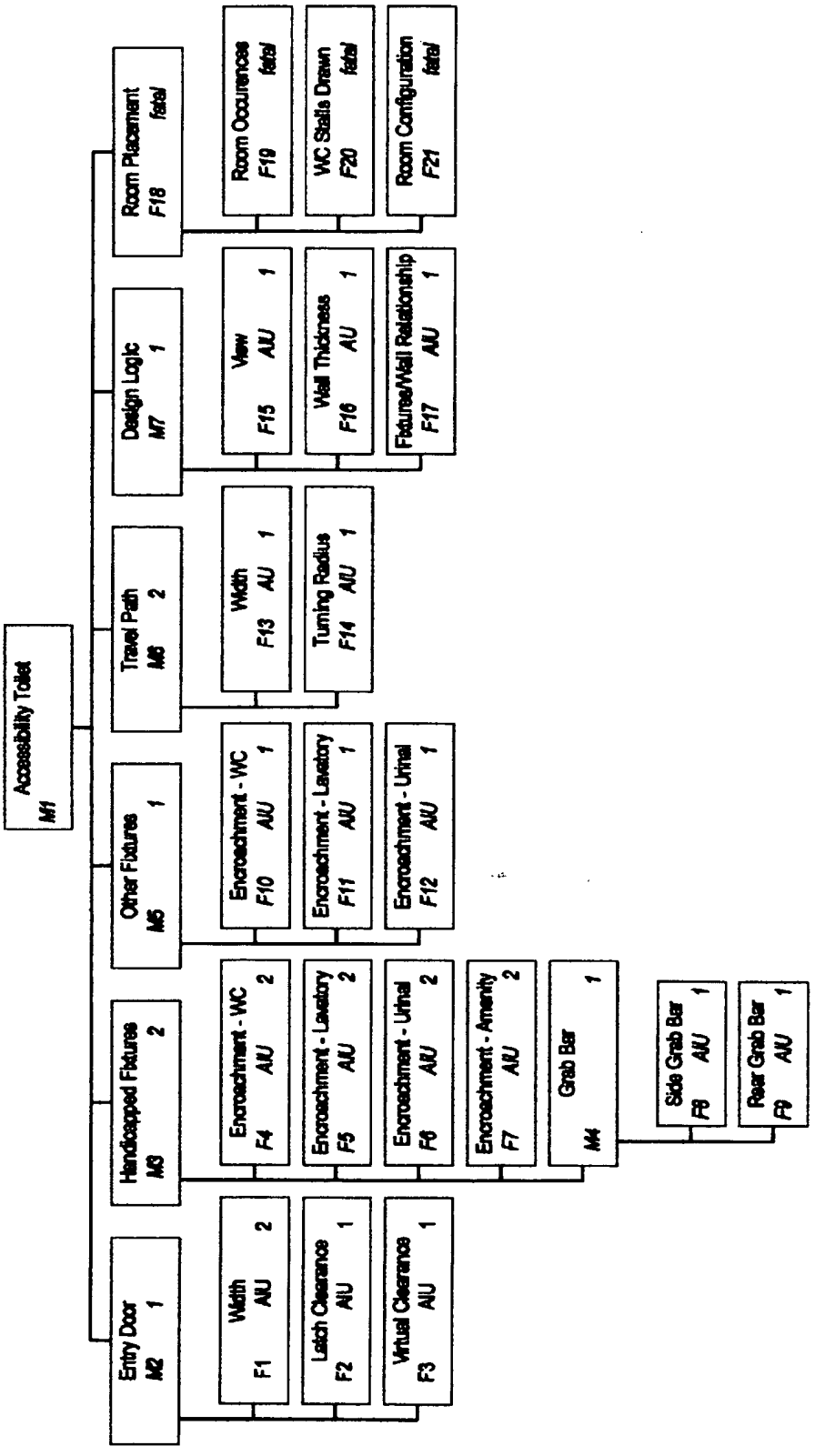

Accessibility Toilet
M1
Entry Door
M2 1
Width
F1 AU 2
Latch Clearance
F2 AU 1
Virtual Clearance
F3 AU 1
Handicapped Fixtures
M3 2
Encroachment - WC
F4 AU 2
Encroachment - Lavatory
F5 AU 2
Encroachment - Urinal
F6 AU 2
Encroachment - Amenity
F7 AU 2
Grab Bar
M4 1
Side Grab Bar
F8 AU 1
Rear Grab Bar
F9 AU 1
Other Fixtures
M5 1
Encroachment - WC
F10 AU 1
Encroachment - Lavatory
F11 AU 1
Encroachment - Urinal
F12 AU 1
Travel Path
M6 2
Width
F13 AU 1
Turning Radius
F14 AU 1
Design Logic
M7 1
View
F15 AU 1
Wall Thickness
F16 AU 1
Fixtures/Wall Relationship
F17 AU 1
Room Placement
F18 fatal
Room Occurrence
F19 fatal
WC Stalls Drawn
F20 fatal
Room Configuration
F21 fatal

FIG. 11

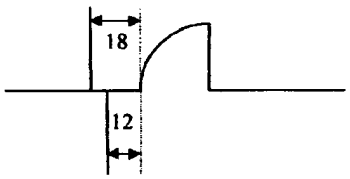
Feature:	F1: Entry Door Width–applies only to HC accessible toilet rooms.
Possible Values:	A, I, U
Multiplier:	2
Rule:	A: All entry doors are 32 to 40 inches wide. I: One or more entry doors are 30 or 42 inches wide. U: Anything else.
Method:	
Comment:	Individual toilet rooms may have more than one entry door. They must all satisfy this requirement.
Question:	

FIG. 12

Feature:	F1a: Entry Door Width: Non-accessible Toilet Rooms.
Possible Values:	A, I, U
Multiplier:	2
Rule:	A: All entry doors to Non-HC toilet rooms are 24" or greater. I: One or more 22" wide. U: Anything else.
Method:	
Comment:	Individual toilet rooms may have more than one entry door. They must all satisfy this requirement.
Question:	

FIG. 13

Feature:	F2: Latch Clearance
Possible Values:	A, I, U
Multiplier:	1
Rule:	In toilet rooms that are author-specified HC accessible, all doors meet the following requirements: A: Conforms to code from both the push and pull side of the door I: One or more 2" off. U: Anything else.
Method:	On the latch side of a door, a wall or other obstruction may not be within 18" on the pull side and 12□ on the push side.



Comment:

Question:

FIG. 14

Feature:	F3: Virtual Clearance
Possible Values:	A, I, U
Multiplier:	1
Rule:	In toilet rooms that are author-specified HC accessible, all doors meet the following requirements: A: Conforms to code from both the push and pull side of the door. (60 pull side, 48 push side). I: One or more 2" off (58 pull side or 46 pull side). U: Anything else.
Method:	On the latch side of a door, a perpendicular wall or other obstruction may not be within 60" on the pull side and 48" on the push side.
Comment:	
Question:	

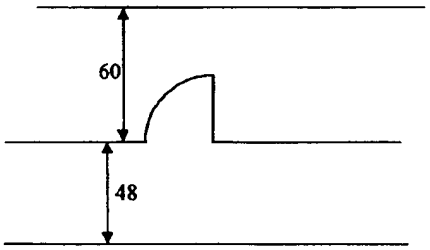


FIG. 15

Feature:	F3a: Two Doors in Series (New Feature) Same as for C5 (Ramp). For accessible toilet rooms only.
Possible Values:	A, I, U
Multiplier:	1
Rule:	A:
	I:
	U: Anything else.
Method:	
Comment:	
Question:	

FIG. 16

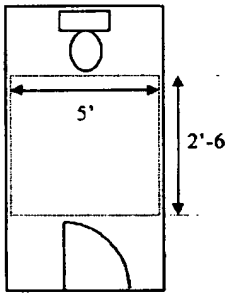
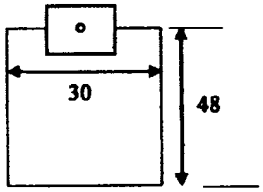
Feature:	F4: Encroachment, HC Water Closet
Possible Values:	A, I, U
Multiplier:	2
Rule:	All HC Water Closets must have:
	A: A minimum 5' x 2'-6 non-encroachment zone, with the water closet centerline at least 18" from side walls. The door swing may **not** enter the non-encroachment zone.
	I: One or more length and/or width of zone is 2" too small, or HC water closet is only 16 – 18" from side wall.
	U: Anything else.
Method:	
Comment:	
Question:	

FIG. 17

Feature:	F5: Encroachment, HC Lavatory
Possible Values:	A, I, U
Multiplier:	2
Rule:	All HC lavatories must have:
	A: A minimum 30 x 48" non-encroachment zone.
	I: One or more length and/or width of zone is 2" too small.
	U: Anything else.
Method:	No object may encroach on the zone as shown below. The door swing may encroach!

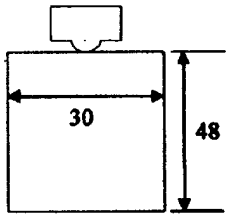


Comment:

Question:

FIG. 18

Feature:	F6: Encroachment, HC Urinal
Possible Values:	A, I, U
Multiplier:	2
Rule:	All HC urinals must have: A: A minimum 30 x 48" zone. I: One or more with length and/or width of zone is 2" too small. U: Anything else.
Method:	No object may encroach on the zone as shown below. The door swing may encroach!



Comment:

Question:

FIG. 19

Feature:	F7: Encroachment, HC Amenity
Possible Values:	A, I, U
Multiplier:	2
Rule:	HC amenity (either a shower or an infant changing table) must have:

Infant Changing Table

A: A minimum 3" x 4" zone

I: Length and/or width of zone is 2" too small

U: Anything else.

Roll-in Shower Stall

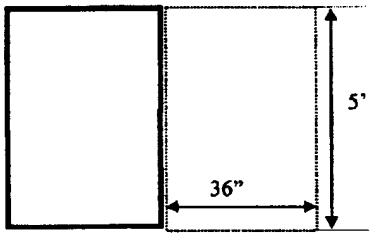
A: A 3' x 5' encroachment zone that abuts the shower door.

I: Length and/or width of zone is 2" too small.

U: Anything else.

Method:

Shower: No object may encroach on the zone as shown below. Door swings may encroach.



Changing Table: No object may encroach on the zone as shown below. Door swings may encroach.

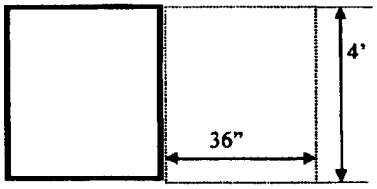


FIG. 20

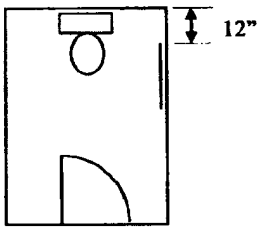
Feature:	F8: Side Grab Bar Location
Possible Values:	A, I, U
Multiplier:	1
Rule:	A: Side grab bars are drawn for HC water closets and are located on the side wall of the stall within 12" of the wall behind the WC. I: One or more within 14". U: Anything else.
Method:	
Comment:	
Question:	

FIG. 21

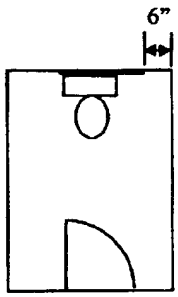
Feature:	F9: Rear Grab Bar Location
Possible Values:	A, I, U
Multiplier:	1
Rule:	A: All rear grab bars are drawn for all HC water closets and are located on the wall behind the WC and up to 6" from the nearest side wall. I: One or more within 8". U: Anything else.
Method:	
Comment:	
Question:	

FIG. 22

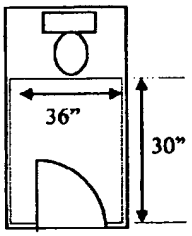
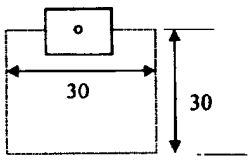
Feature:	F10: Encroachment, Non-Accessible Water Closet Stall
Possible Values:	A, I, U
Multiplier:	2
Rule:	All Non-HC water closets must have: A: A minimum of 30" wide and 54" deep. A: I: One or more stalls 2" too narrow and/or too shallow. U: Anything else.
Method:	
Comment:	
Question:	

FIG. 23

Feature:	F11: Encroachment, Lavatory
Possible Values:	A, I, U
Multiplier:	2
Rule:	All Non-HC lavatories must have: A: A minimum 30 x 30" non-encroachment zone. I: One or more length and/or width of zone is 2" too small. U: Anything else.
Method:	No object may encroach on the zone as shown below. Door swings may encroach.

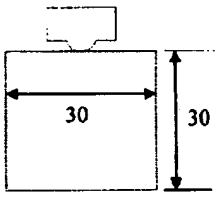


Comment:

Question:

FIG. 24

Feature:	F12: Encroachment, Urinal
Possible Values:	A, I, U
Multiplier:	2
Rule:	All Non-HC urinals must have: A: A minimum 30 x 30" non-encroachment zone. I: One or more length and/or width of zone is 2" too small. U: Anything else.
Method:	No object may encroach on the zone as shown below. Door swings may encroach.



Comment:

Question:

FIG. 25

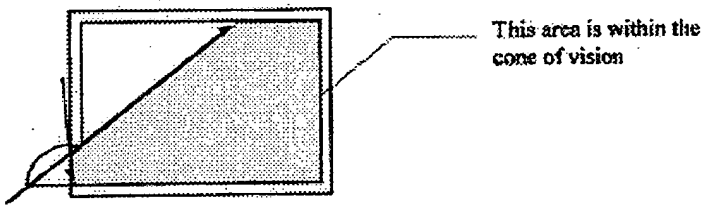
Feature:	F13: Travel Path Width
Possible Values:	A, I, U
Multiplier:	1
Rule:	A: Travel paths from every entry door of a toilet room must maintain a minimum width of 36" to each fixture in that toilet room. I: A minimum width of 30" is maintained. U: Anything else.
Method:	
Comment:	
Question:	

FIG. 26

Feature:	F14: Turning Radius
Possible Values:	A, I, U
Multiplier:	1
Rule:	In toilet rooms that are author-specified HC accessible: A: A turning circle of a minimum of 60" in diameter must exist somewhere within the toilet room, and must be connected to the travel path. I: 58". U: Anything else.
Method:	
Comment:	
Question:	

FIG. 27

Feature:	F15: View
Possible Values:	A, I, U
Multiplier:	1
Rule:	A: For all rooms, the view cone includes no stall doors or urinals. I: For one or more rooms the view cone includes one or more stall doors but no urinals. U: For one or more rooms the view cone includes one or more urinals.
Method:	The view cone is everything that can be seen walking past the door. An outswinging door in the open position (shown below) may itself screen the view somewhat.



Comment:

Question:

FIG. 28

Feature:	F16: Wall Thickness
Possible Values:	A, U
Multiplier:	1
Rule:	A: All water closets, and urinals should abut 8" walls for their full width. U: One or more do not.
Method:	
Comment:	The candidate can "thicken" the existing 4" walls by using the wall tool to increase the thickness to 8" (or more).
Question:	

FIG. 29

Feature:	F17: Fixtures / Wall Relationship
Possible Values:	A, I, U
Multiplier:	1
Rule:	A: All fixtures are located on or within 2" of the wall.
	I: One or more fixtures are 4" from the wall or 2" into the wall.
	U: Anything else.
Method:	
Comment:	
Question:	

FIG. 30

Feature:	F18: Room Placement
Possible Values:	A, F
Multiplier:	fatal
Rule:	A: All toilet rooms are configured within footprint.
	F: Anything else.
Method:	
Comment:	
Question:	

FIG. 31

Feature:	F19: Toilet Room Designed
Possible Values:	A, F
Multiplier:	fatal
Rule:	A: All prescribed toilet rooms are designed.
	F: Anything else.
Method:	A toilet room is considered designed if it is enclosed, it is accessible from public space, and it is labeled with a single label.
Comment:	
Question:	

FIG. 32

Feature:	F20: Water Closet Stalls Drawn
Possible Values:	A, F
Multiplier:	fatal
Rule:	A: All water closets are enclosed in stalls with one door 24" wide or wider. F: Anything else.
Method:	
Comment:	
Question:	

FIG. 33

Feature:	F21: Room Configuration
Possible Values:	A, F
Multiplier:	fatal
Rule:	A: Each toilet room must have the prescribed fixtures (HC and non-HC water closets, urinals and lavatories, and shower or infant changing table). F: Anything else.
Method:	
Comment:	
Question:	

FIG. 34

M1: Master

Composed of:	Matrices/features	Multiplier	Possible Values
	M2 Entry Door	1	AIU
	M3 Handicapped Features	2	AIU
	M5 Other Fixtures	1	AIU
	M6 Travel Path	2	AIU
	M7 Design Logic	1	AIU

U's

I's

M1	0	1	2	3	4	5	6	7	8	9	10
0	A	A	I	I	U						
1	A	A	I	U							
2	A	I	I	U							
3	A	I	I	U							
4	I	I	U	U							
5	I	U	U								
6	U										
7											
8											
9											
10											

FIG. 35

M2: Entry Door

Composed of:	Matrices/features	Multiplier	Possible Values
	F1 Width	2	AIU
	F2 Latch Clearance	1	AIU
	F3 Virtual Clearance	1	AIU

U's

M2	0	1	2	3	4	5	6	7	8	9	10
0	A	I	U								
1	A	I	U								
2	I	U									
3	U										
4											
5											
6											
7											
8											
9											
10											

I's

FIG. 36

M3: Handicapped Fixtures

Composed of:	Matrices/features	Multiplier	Possible Values
	F4 Encroachment - WC	2	AIU
	F5 Encroachement - Lavatory	2	AIU
	F6 Encroachment - Urinal	2	AIU
	F7 Encroachment - Amenity	2	AIU
	M4 Grab Bar	1	AIU

U's

I's

M3	0	1	2	3	4	5	6	7	8	9	10
0	A	A	I	I	U						
1	A		I		U						
2	A	I	I	I	U						
3	I		I		U						
4	I	I	U								
5	I	U									
6	I	U									
7	U										
8											
9											
10											

FIG. 37

M4: Grab Bar

Composed of:	Matrices/features	Multiplier	Possible Values
	F8 Side Grab Bar	1	AIU
	F9 Rear Grab Bar	1	AIU

U's

I's

M4	0	1	2	3	4	5	6	7	8	9	10
0	A	I	U								
1	I	U									
2	U										
3											
4											
5											
6											
7											
8											
9											
10											

FIG. 38

M5: Other Fixtures

Composed of:	Matrices/features	Multiplier	Possible Values
	F10 Encroachment - WC	1	AIU
	F11 Encroachment - Lavatory	1	AIU
	F12 Encroachment - Urinal	1	AIU

U's

I's

M5	0	1	2	3	4	5	6	7	8	9	10
0	A	I	U								
1	A	U									
2	I	U									
3	U										
4											
5											
6											
7											
8											
9											
10											

FIG. 39

M6: Travel Path

Composed of:	Matrices/features	Multiplier	Possible Values
	F13 Width	1	AU
	F14 Turning Radius	1	AIU

U's

I's

M6	0	1	2	3	4	5	6	7	8	9	10
0	A	I	U								
1	I	U									
2											
3											
4											
5											
6											
7											
8											
9											
10											

FIG. 40

M7: Design Logic

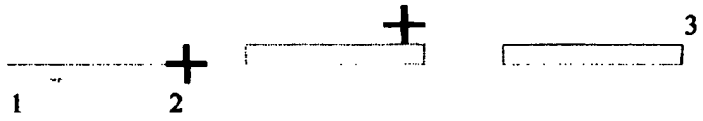
Composed of:	Matrices/features	Multiplier	Possible Values
	F15 View	1	AIU
	F16 Wall Thickness	1	AU
	F17 Fixtures / Wall Relationship	1	AIU

U's

I's	M7	0	1	2	3	4	5	6	7	8	9	10
	0	A	I	U								
	1	A	U									
	2	I	U									
	3											
	4											
	5											
	6											
	7											
	8											
	9											
	10											

FIG. 41

The 4" wall is drawn in the following way:



The endpoint of that line is fixed by click #2. When the cursor is moved perpendicularly to the line (above or below), 3 dotted lines show the candidate the wall that will be formed. The wall should be the length of the rubberbanding line, and 4" in width, regardless of how far the cursor is Click #1 starts a rubberbanding line. moved from the line. Click #3 completes the wall. Allow an unlimited number to be drawn.

FIG. 42

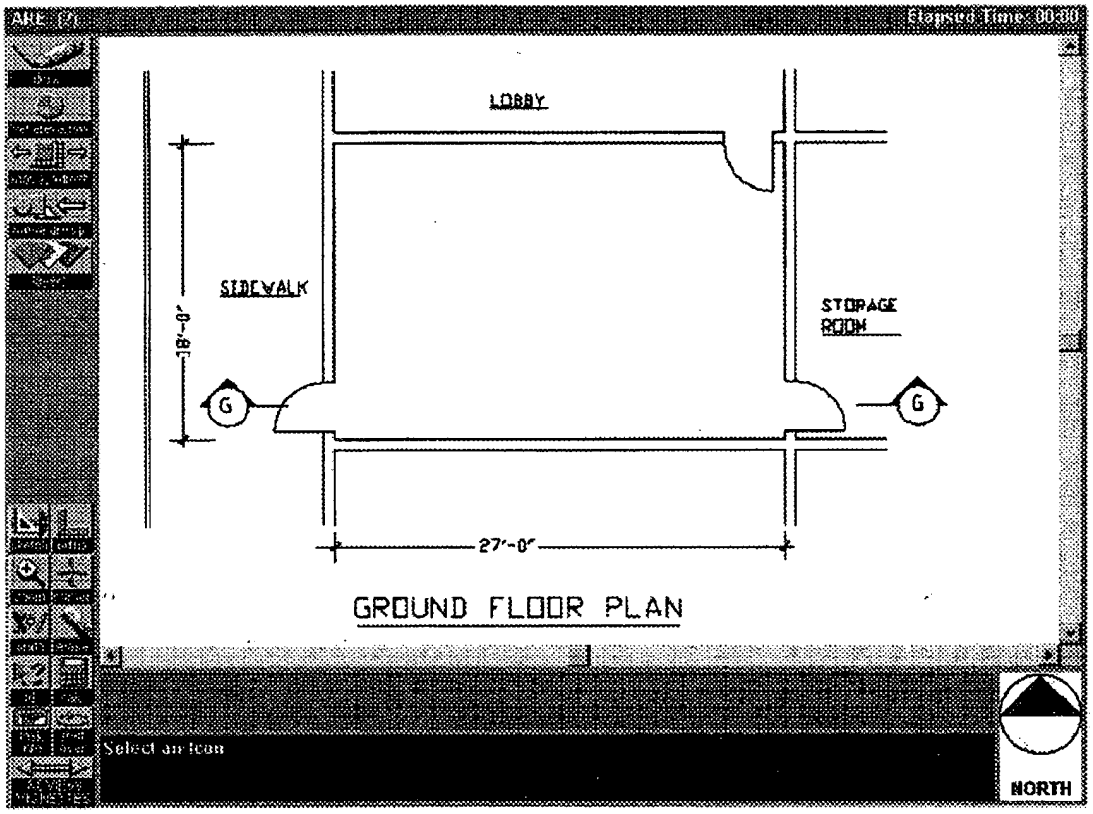

LOBBY
SIDEWALK
STORAGE ROOM
18'-0"
27'-0"
GROUND FLOOR PLAN
NORTH

FIG. 43

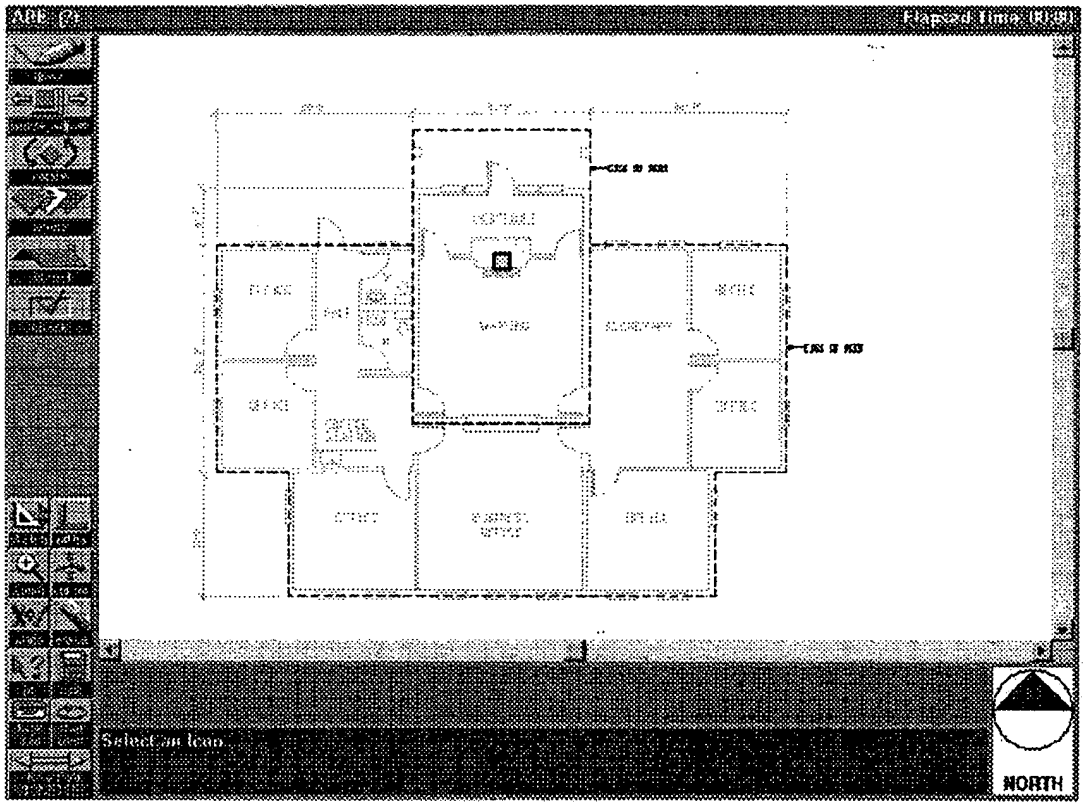


FIG. 44

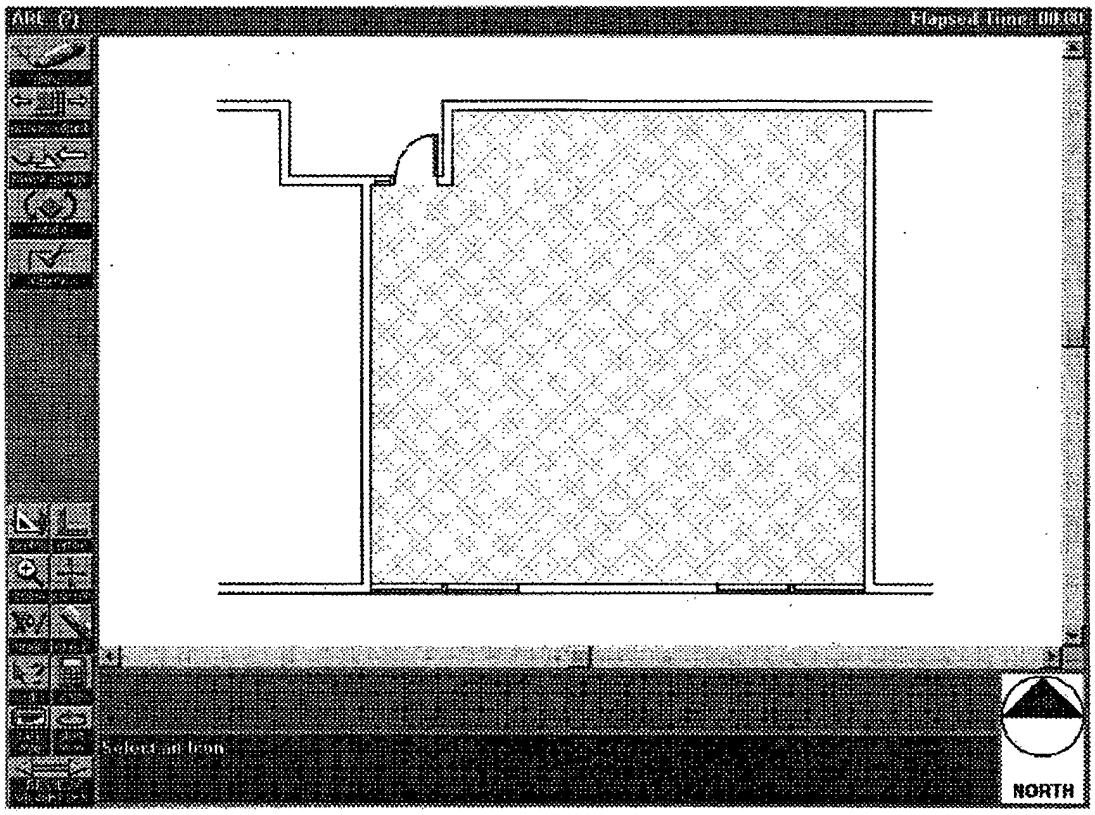


FIG. 45

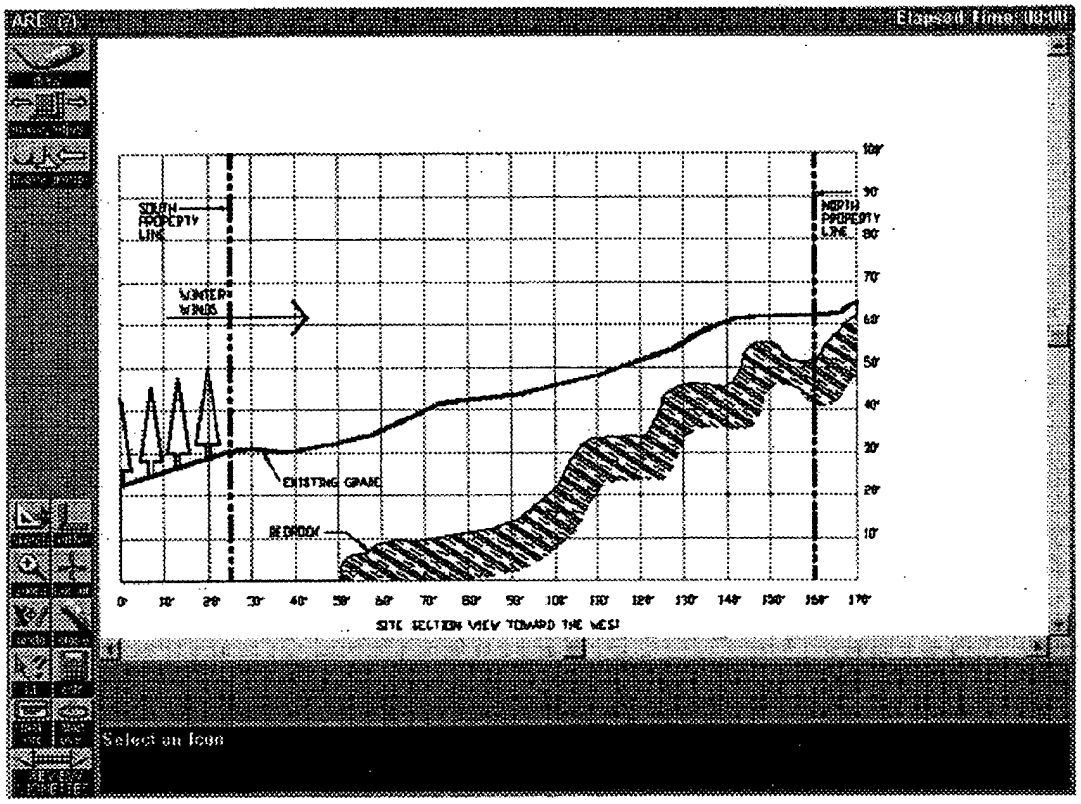

SOUTH PROPERTY LINE
WINTER WINDS
NORTH PROPERTY LINE
EXISTING GRADE
BEDROCK
SITE SECTION VIEW TOWARD THE WEST
Select an Icon

FIG. 46

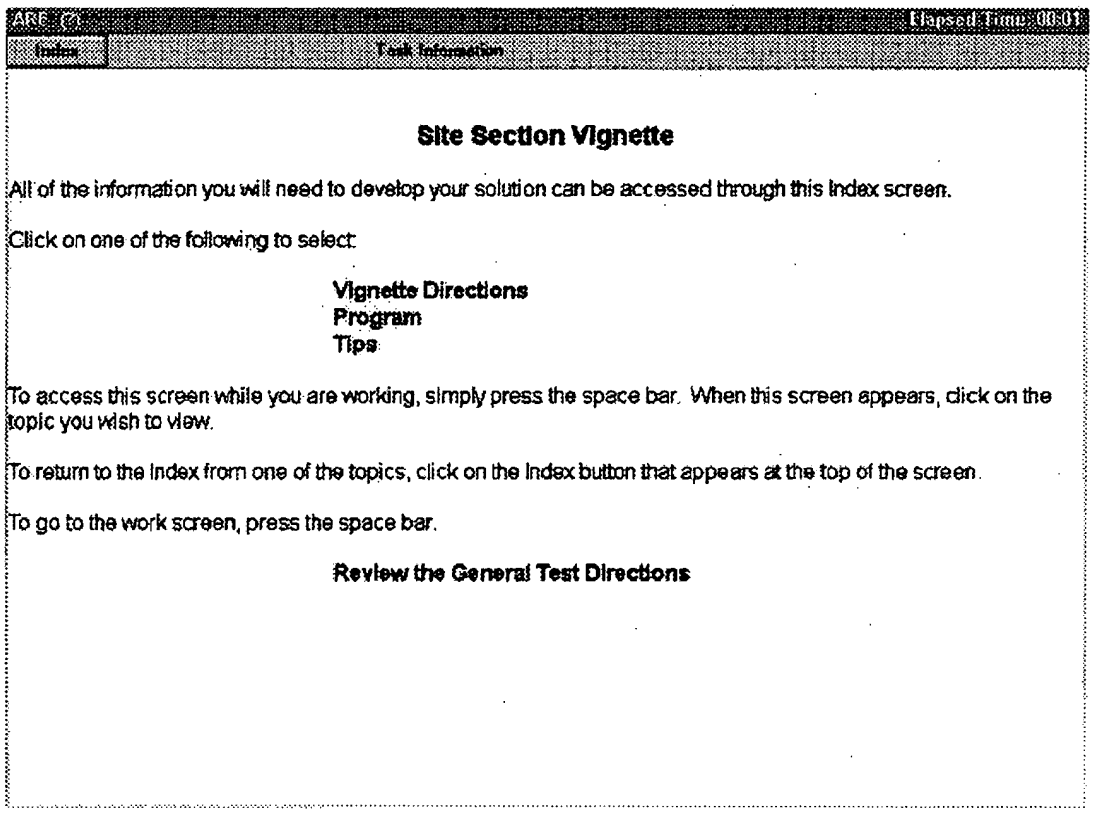

ARE
Elapsed Time: 00:01
Index
Task Information
Site Section Vignette
All of the information you will need to develop your solution can be accessed through this index screen.
Click on one of the following to select:
Vignette Directions
Program
Tips
To access this screen while you are working, simply press the space bar. When this screen appears, click on the topic you wish to view.
To return to the Index from one of the topics, click on the Index button that appears at the top of the screen.
To go to the work screen, press the space bar.
Review the General Test Directions

FIG. 47

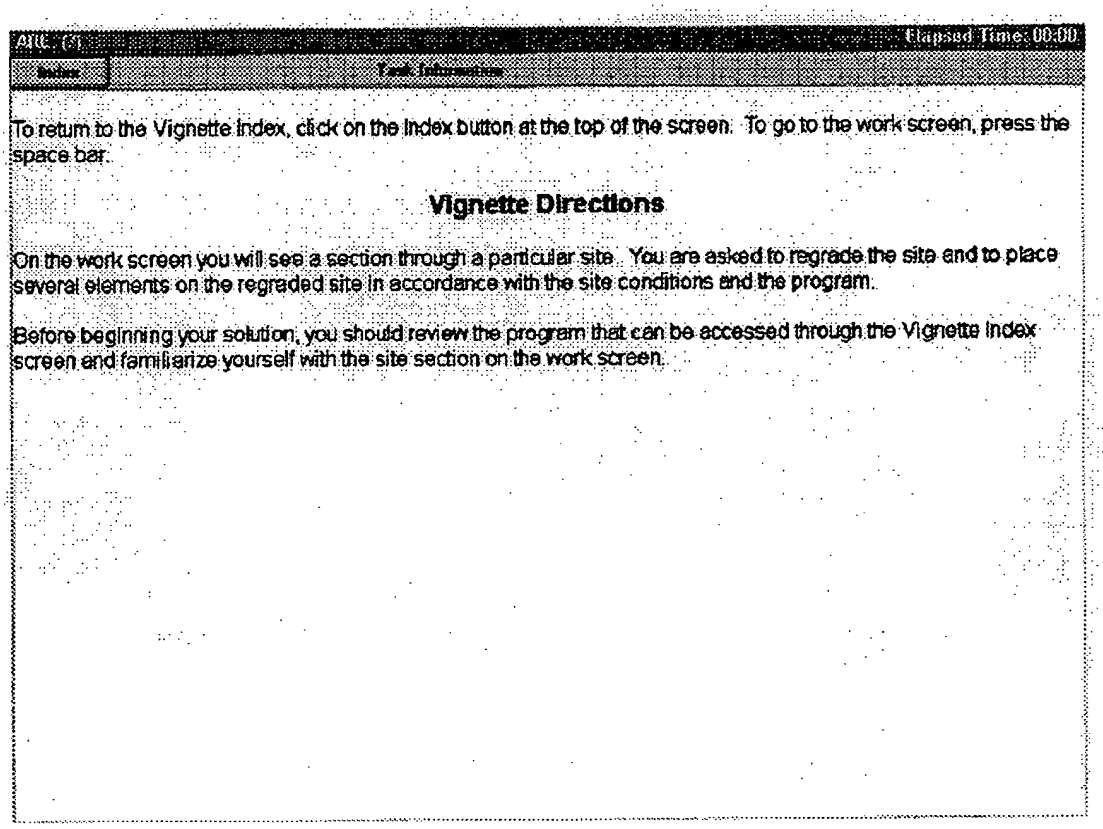

Elapsed Time: 00:00
To return to the Vignette Index, click on the Index button at the top of the screen. To go to the work screen, press the space bar.
Vignette Directions
On the work screen you will see a section through a particular site. You are asked to regrade the site and to place several elements on the regraded site in accordance with the site conditions and the program.
Before beginning your solution, you should review the program that can be accessed through the Vignette Index screen and familiarize yourself with the site section on the work screen.

FIG. 48

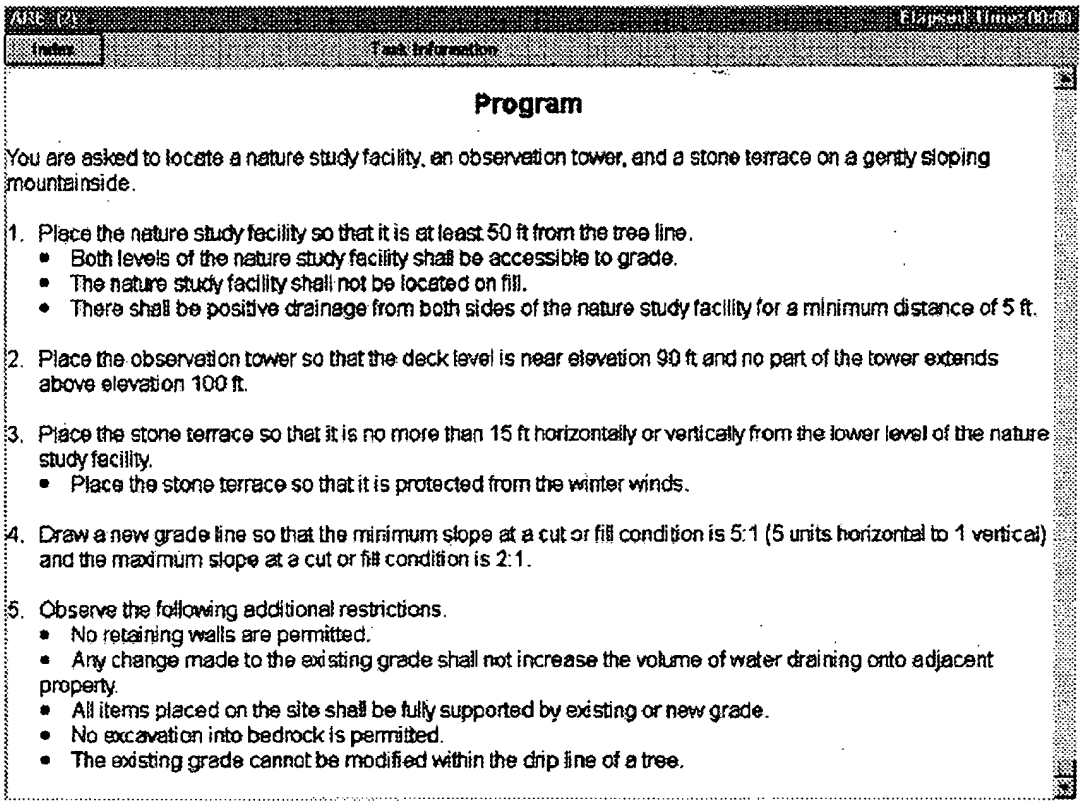

Index
Task Information
Program
You are asked to locate a nature study facility, an observation tower, and a stone terrace on a gently sloping mountainside.
1. Place the nature study facility so that it is at least 50 ft from the tree line.
• Both levels of the nature study facility shall be accessible to grade.
• The nature study facility shall not be located on fill.
• There shall be positive drainage from both sides of the nature study facility for a minimum distance of 5 ft.
2. Place the observation tower so that the deck level is near elevation 90 ft and no part of the tower extends above elevation 100 ft.
3. Place the stone terrace so that it is no more than 15 ft horizontally or vertically from the lower level of the nature study facility.
• Place the stone terrace so that it is protected from the winter winds.
4. Draw a new grade line so that the minimum slope at a cut or fill condition is 5:1 (5 units horizontal to 1 vertical) and the maximum slope at a cut or fill condition is 2:1.
5. Observe the following additional restrictions.
• No retaining walls are permitted.
• Any change made to the existing grade shall not increase the volume of water draining onto adjacent property.
• All items placed on the site shall be fully supported by existing or new grade.
• No excavation into bedrock is permitted.
• The existing grade cannot be modified within the drip line of a tree.

FIG. 49

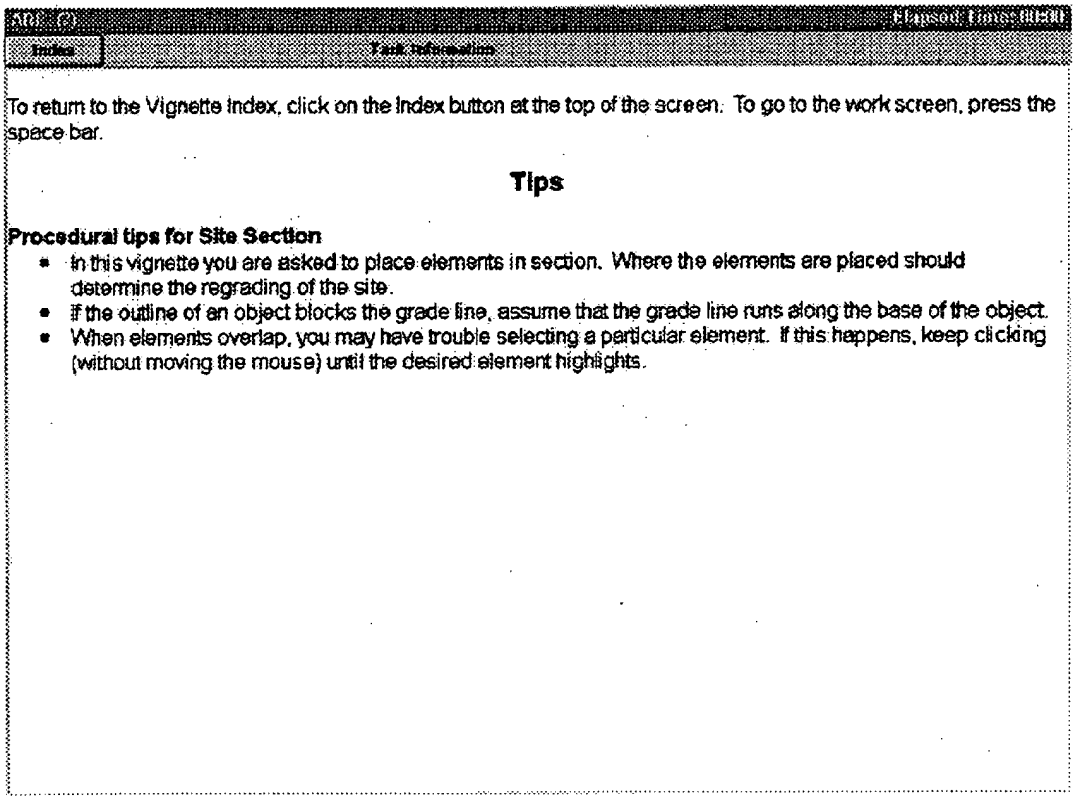

Index
To return to the Vignette Index, click on the Index button at the top of the screen. To go to the work screen, press the space bar.
Tips
Procedural tips for Site Section
In this vignette you are asked to place elements in section. Where the elements are placed should determine the regrading of the site.
If the outline of an object blocks the grade line, assume that the grade line runs along the base of the object.
When elements overlap, you may have trouble selecting a particular element. If this happens, keep clicking (without moving the mouse) until the desired element highlights.

FIG. 50

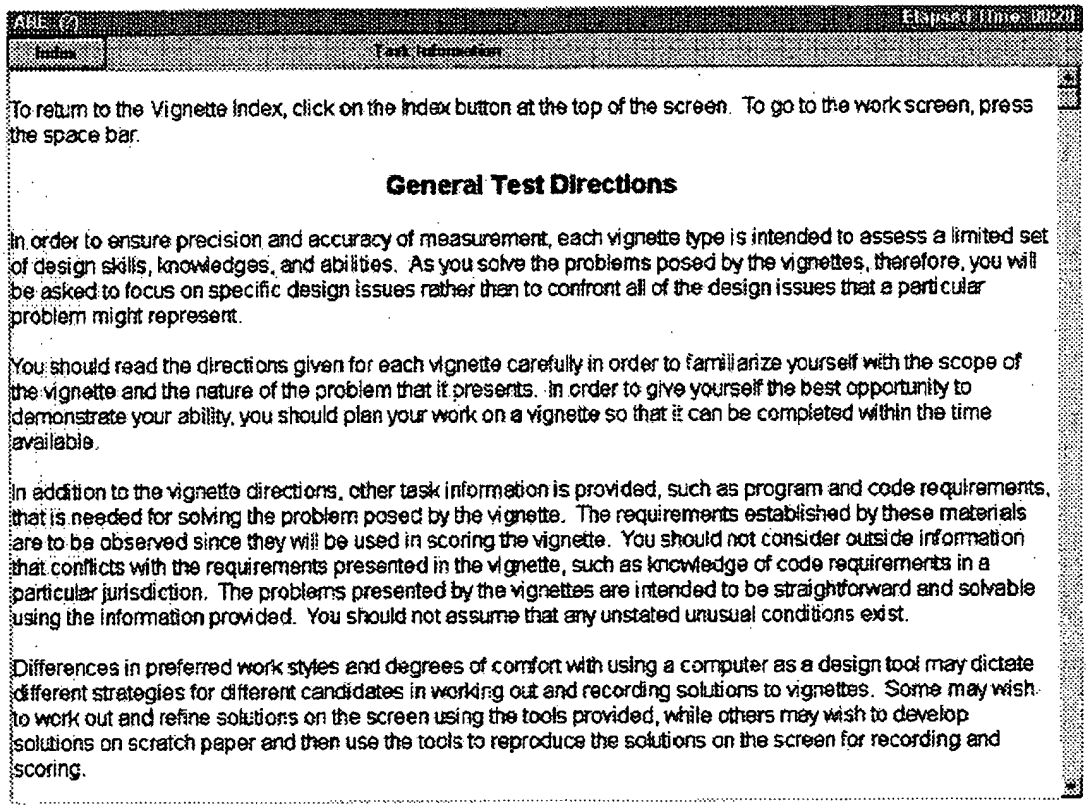

Index
Task Information
To return to the Vignette Index, click on the Index button at the top of the screen. To go to the work screen, press the space bar.
General Test Directions
In order to ensure precision and accuracy of measurement, each vignette type is intended to assess a limited set of design skills, knowledges, and abilities. As you solve the problems posed by the vignettes, therefore, you will be asked to focus on specific design issues rather than to confront all of the design issues that a particular problem might represent.
You should read the directions given for each vignette carefully in order to familiarize yourself with the scope of the vignette and the nature of the problem that it presents. In order to give yourself the best opportunity to demonstrate your ability, you should plan your work on a vignette so that it can be completed within the time available.
In addition to the vignette directions, other task information is provided, such as program and code requirements, that is needed for solving the problem posed by the vignette. The requirements established by these materials are to be observed since they will be used in scoring the vignette. You should not consider outside information that conflicts with the requirements presented in the vignette, such as knowledge of code requirements in a particular jurisdiction. The problems presented by the vignettes are intended to be straightforward and solvable using the information provided. You should not assume that any unstated unusual conditions exist.
Differences in preferred work styles and degrees of comfort with using a computer as a design tool may dictate different strategies for different candidates in working out and recording solutions to vignettes. Some may wish to work out and refine solutions on the screen using the tools provided, while others may wish to develop solutions on scratch paper and then use the tools to reproduce the solutions on the screen for recording and scoring.

FIG. 51(a)

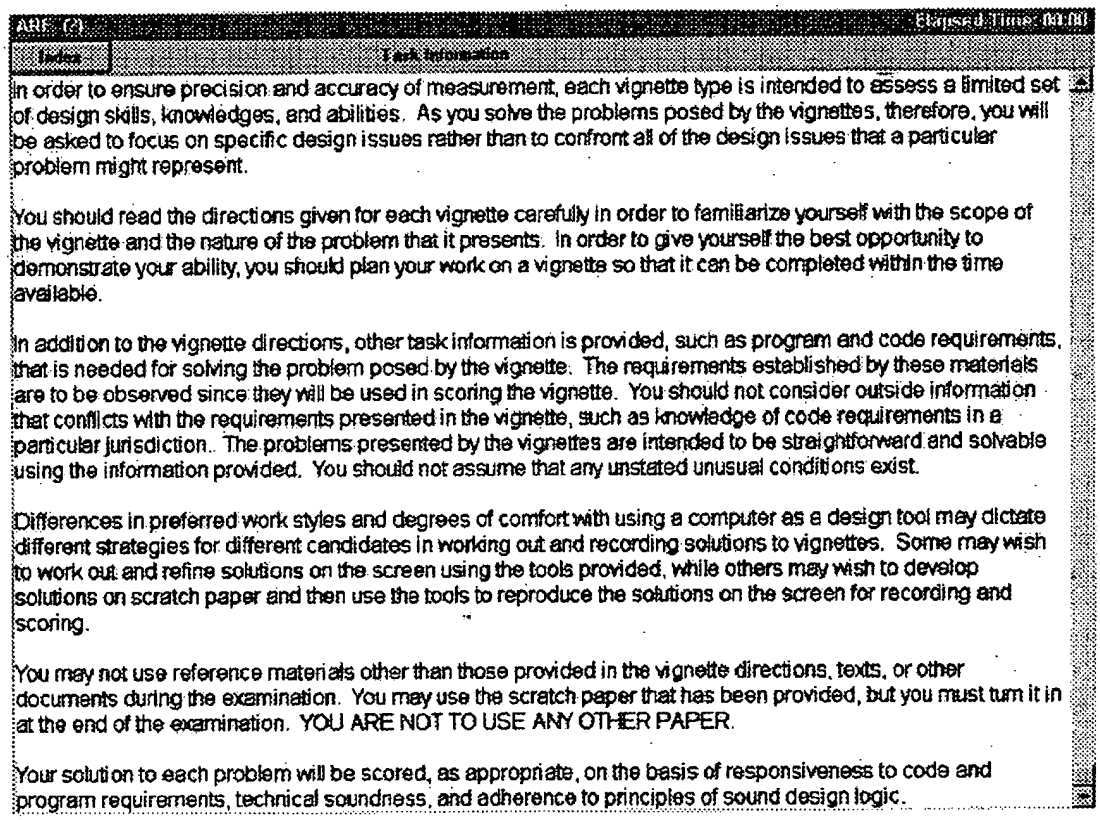

ARE (2)
Elapsed Time: 01:00
Index
Task Information
In order to ensure precision and accuracy of measurement, each vignette type is intended to assess a limited set of design skills, knowledges, and abilities. As you solve the problems posed by the vignettes, therefore, you will be asked to focus on specific design issues rather than to confront all of the design issues that a particular problem might represent.
You should read the directions given for each vignette carefully in order to familiarize yourself with the scope of the vignette and the nature of the problem that it presents. In order to give yourself the best opportunity to demonstrate your ability, you should plan your work on a vignette so that it can be completed within the time available.
In addition to the vignette directions, other task information is provided, such as program and code requirements, that is needed for solving the problem posed by the vignette. The requirements established by these materials are to be observed since they will be used in scoring the vignette. You should not consider outside information that conflicts with the requirements presented in the vignette, such as knowledge of code requirements in a particular jurisdiction. The problems presented by the vignettes are intended to be straightforward and solvable using the information provided. You should not assume that any unstated unusual conditions exist.
Differences in preferred work styles and degrees of comfort with using a computer as a design tool may dictate different strategies for different candidates in working out and recording solutions to vignettes. Some may wish to work out and refine solutions on the screen using the tools provided, while others may wish to develop solutions on scratch paper and then use the tools to reproduce the solutions on the screen for recording and scoring.
You may not use reference materials other than those provided in the vignette directions, texts, or other documents during the examination. You may use the scratch paper that has been provided, but you must turn it in at the end of the examination. YOU ARE NOT TO USE ANY OTHER PAPER.
Your solution to each problem will be scored, as appropriate, on the basis of responsiveness to code and program requirements, technical soundness, and adherence to principles of sound design logic.

FIG. 51(b)

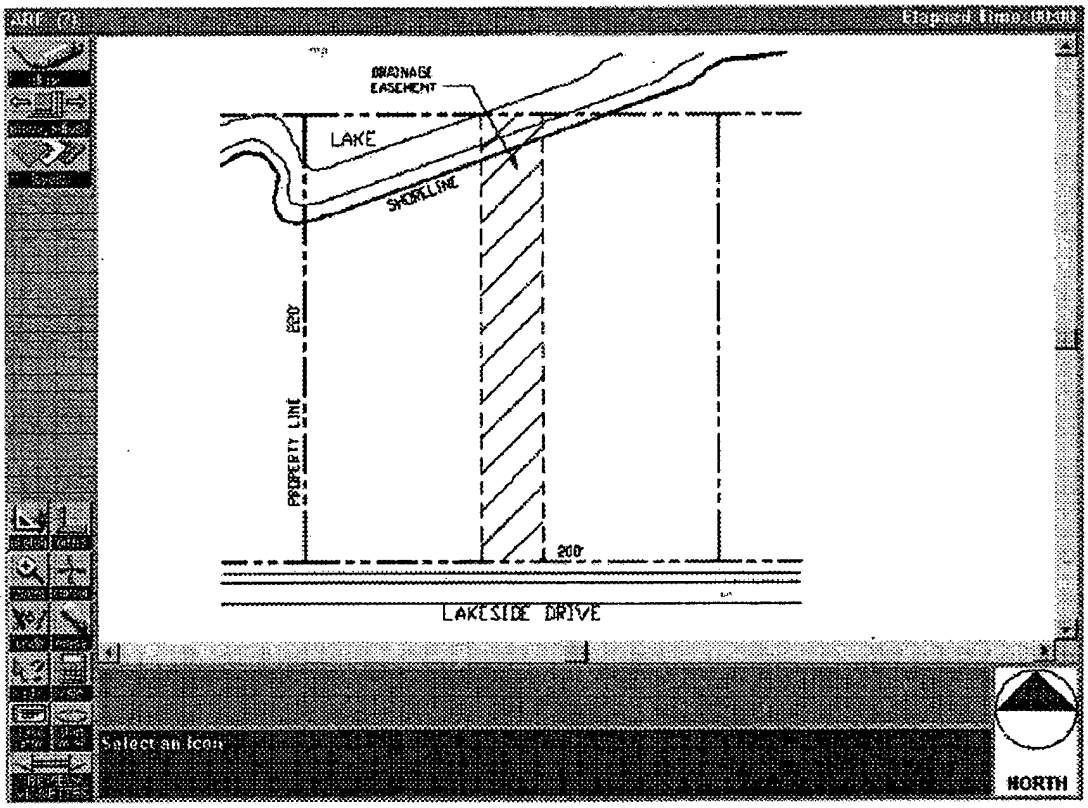

DRAINAGE EASEMENT
LAKE
SHORELINE
220'
PROPERTY LINE
200'
LAKESIDE DRIVE
Select an Icon
NORTH

FIG. 52

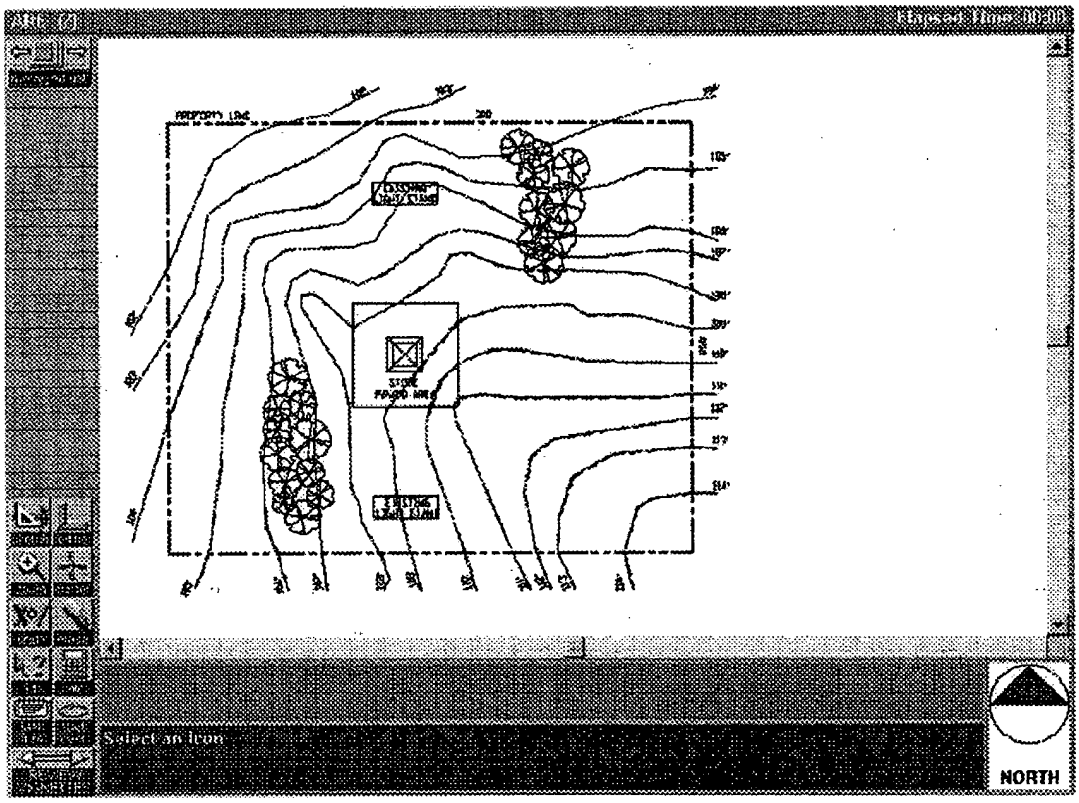


FIG. 53

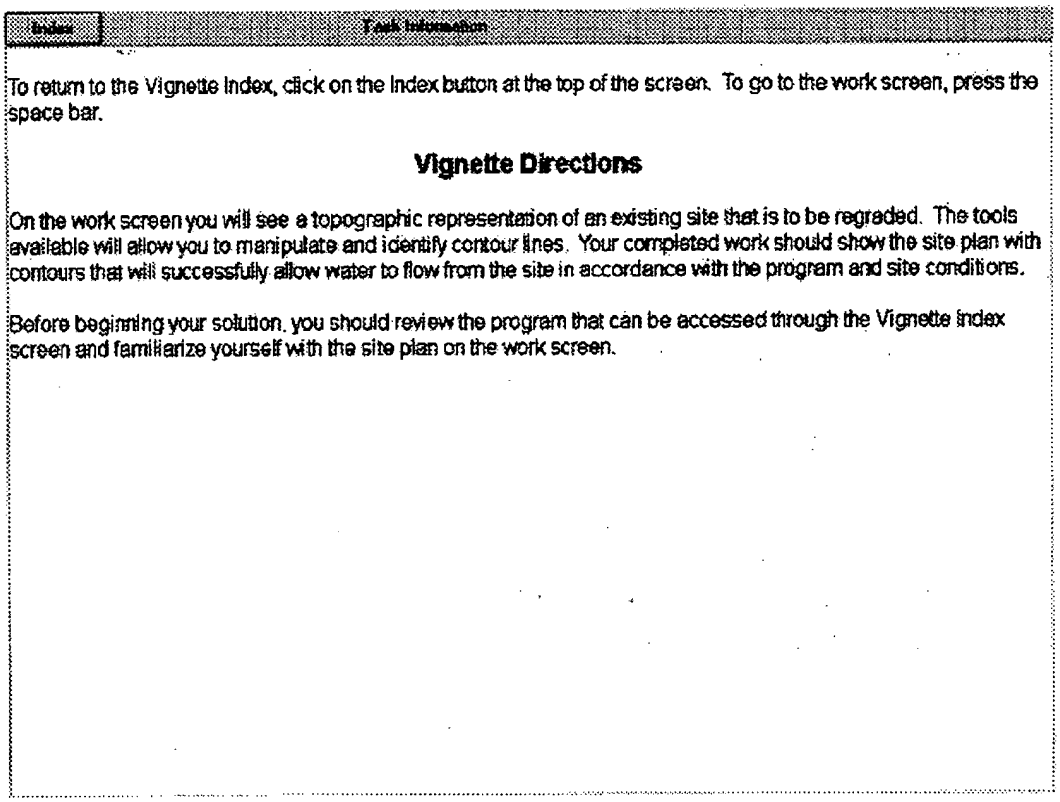

Index
Task Information
To return to the Vignette Index, click on the Index button at the top of the screen. To go to the work screen, press the space bar.
Vignette Directions
On the work screen you will see a topographic representation of an existing site that is to be regraded. The tools available will allow you to manipulate and identify contour lines. Your completed work should show the site plan with contours that will successfully allow water to flow from the site in accordance with the program and site conditions.
Before beginning your solution, you should review the program that can be accessed through the Vignette Index screen and familiarize yourself with the site plan on the work screen.

FIG. 54

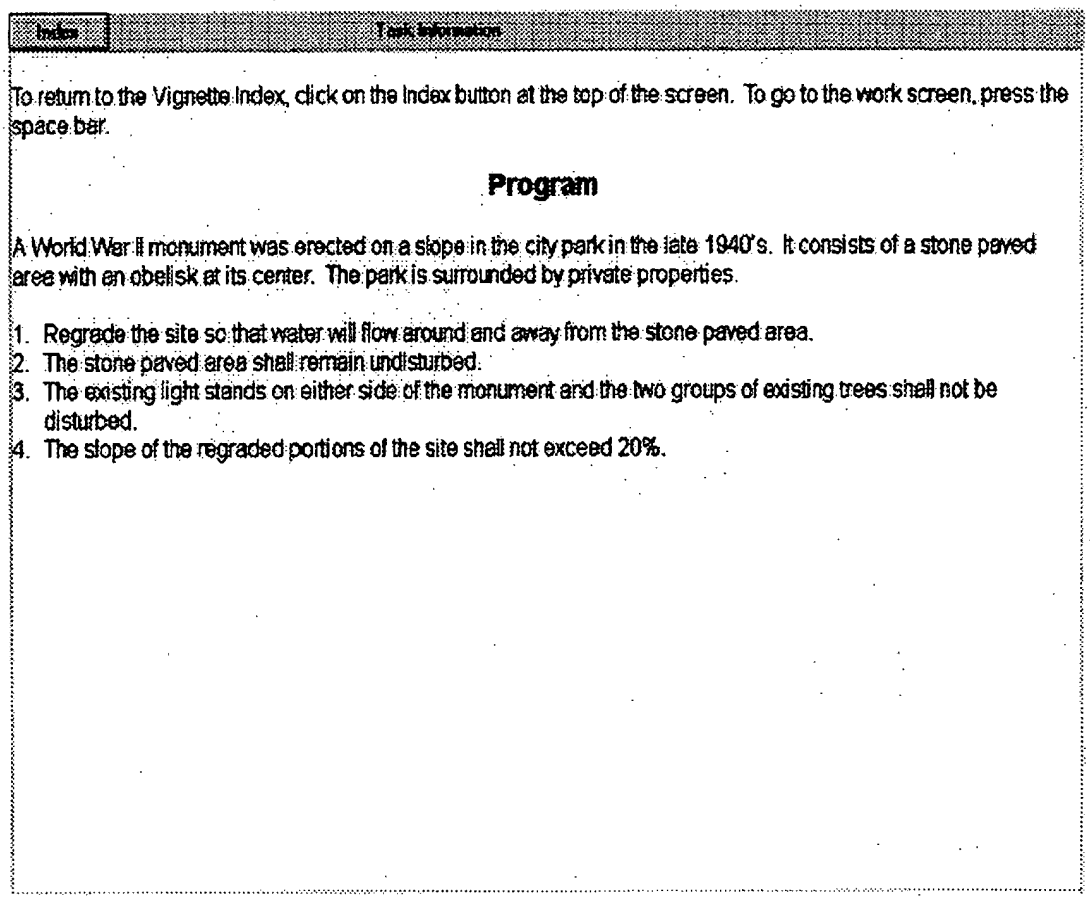

Index
Task Information
To return to the Vignette Index, click on the Index button at the top of the screen. To go to the work screen, press the space bar.
Program
A World War II monument was erected on a slope in the city park in the late 1940's. It consists of a stone paved area with an obelisk at its center. The park is surrounded by private properties.
1. Regrade the site so that water will flow around and away from the stone paved area.
2. The stone paved area shall remain undisturbed.
3. The existing light stands on either side of the monument and the two groups of existing trees shall not be disturbed.
4. The slope of the regraded portions of the site shall not exceed 20%.

FIG. 55

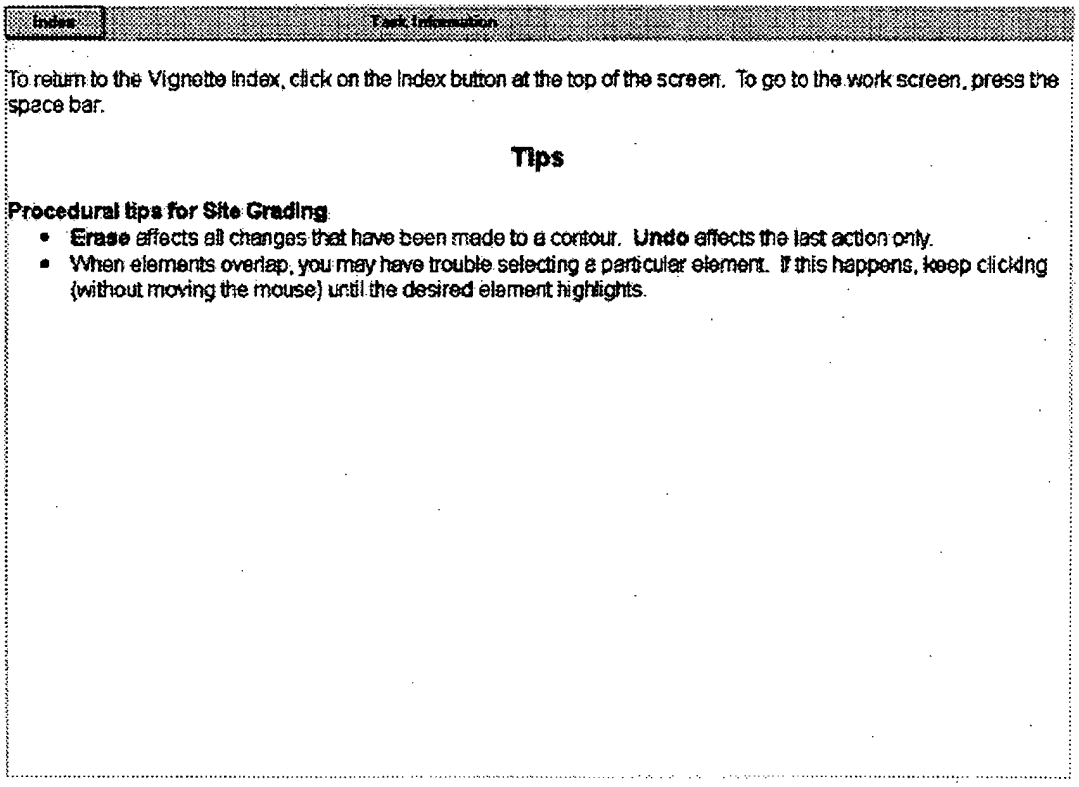

Index
Task Information
To return to the Vignette Index, click on the Index button at the top of the screen. To go to the work screen, press the space bar.
Tips
Procedural tips for Site Grading
Erase effects all changes that have been made to a contour. Undo effects the last action only.
When elements overlap, you may have trouble selecting a particular element. If this happens, keep clicking (without moving the mouse) until the desired element highlights.

FIG. 56

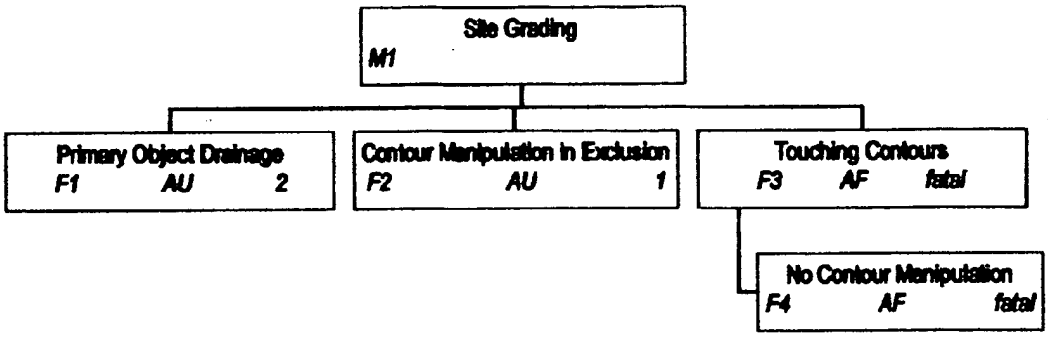

Site Grading
M1
Primary Object Drainage
F1 AU 2
Contour Manipulation In Exclusion
F2 AU 1
Touching Contours
F3 AF fatal
No Contour Manipulation
F4 AF fatal

FIG. 57

Feature:	F1: Primary Object Drainage
Possible Values:	A, U
Multiplier:	
Rule:	A: The amount of water draining across the primary object is decreased by <Min%ImproveForA> (use 75%). U: It isn't.
Method:	The amount of water that crosses the primary object before the candidate's contour alterations must be measured. If the alterations result in a Min%ImproveForA> decrease in the amount of water entering the primary object from the site, an A is assigned.
Comment:	
Question:	

FIG. 58

Feature:	F2: Cut or Fill Within Exclusionary Objects or Over Property Line
Possible Values:	A, U
Multiplier:	
Rule:	A: Contour manipulation has not taken place within exclusionary objects, beyond <ExclusionaryObjectBuffer> (use 300mm) or beyond the PropertyLine beyond <ExclusionaryObjectBuffer>. U: Anything else.
Method:	Manipulation is considered to have happen if contours within exclusionary object deviate more than <ExclusionaryObjectBuffer> from their initial positions.
Comment:	
Question:	

FIG. 59

Feature:	F3: Touching or Overlapping Contours
Possible Values:	Fatal
Multiplier:	
Rule:	A: Contours of differing elevations do not touch or overlap.
	F: Anything else.
Method:	
Comment:	
Question:	

FIG. 60

Feature:	F4: No Contour Manipulation
Possible Values:	Fatal
Multiplier:	
Rule:	A: The candidate has manipulated (drawn) one or more contours.
	F: Anything else.
Method:	
Comment:	
Question	

FIG. 61

M1: Site Section

Composed of:	Matrices/features	Multiplier	Possible Values
	F1 Slope Drainage	1	AU
	F2 Primary Object Drainage	2	AU

U's

I's

M1	0	1	2	3	4	5	6	7	8	9	10
0	A	I									
1	A	I									
2											
3											
4											
5											
6											
7											
8											
9											
10											

FIG. 62

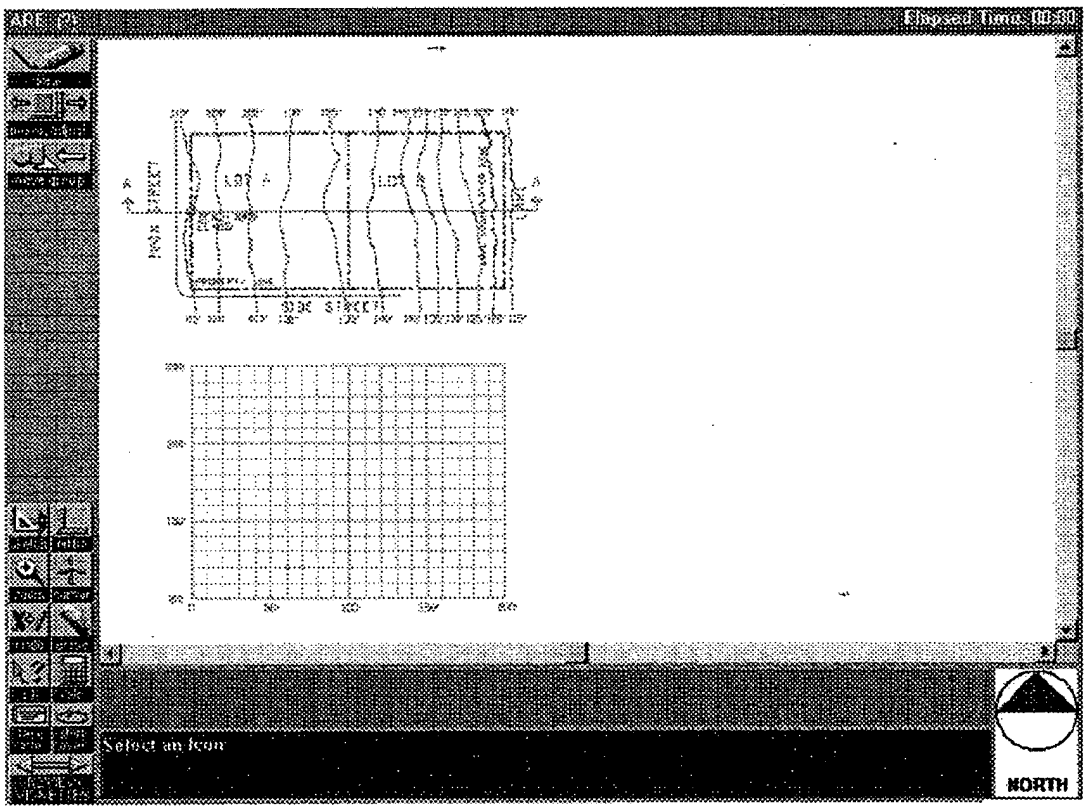


FIG. 63

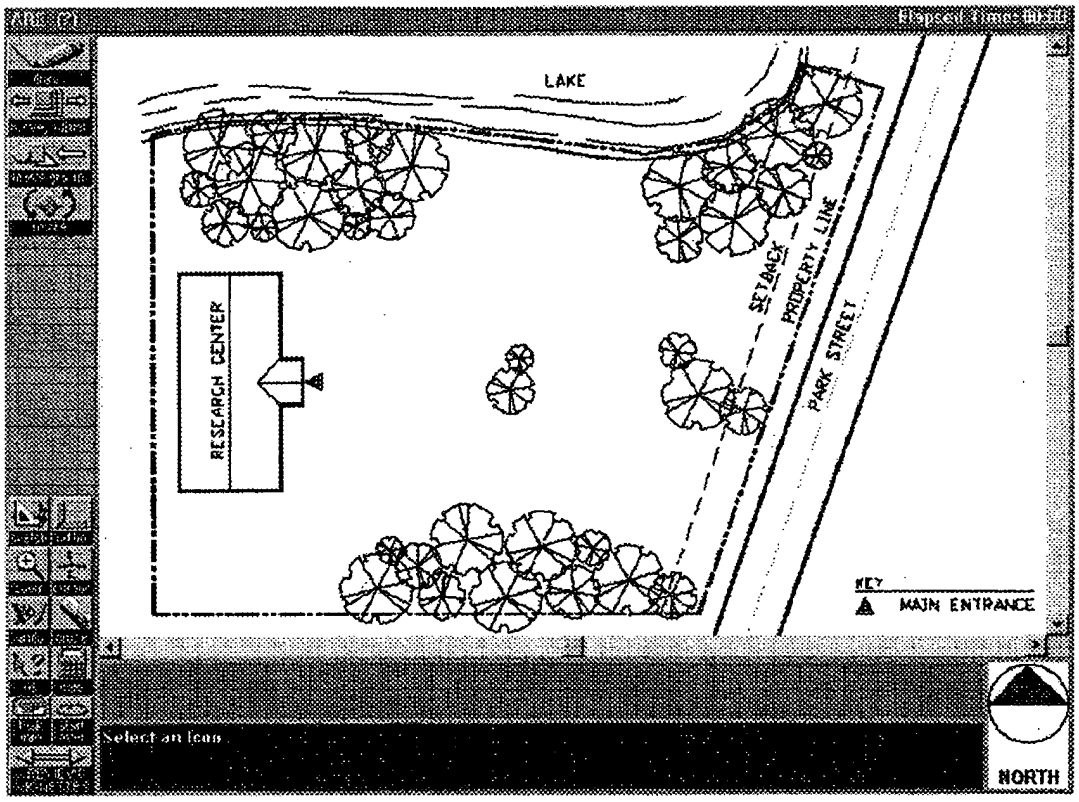

LAKE
RESEARCH CENTER
SETBACK
PROPERTY LINE
PARK STREET
KEY
MAIN ENTRANCE
Select an Icon
NORTH

FIG. 64

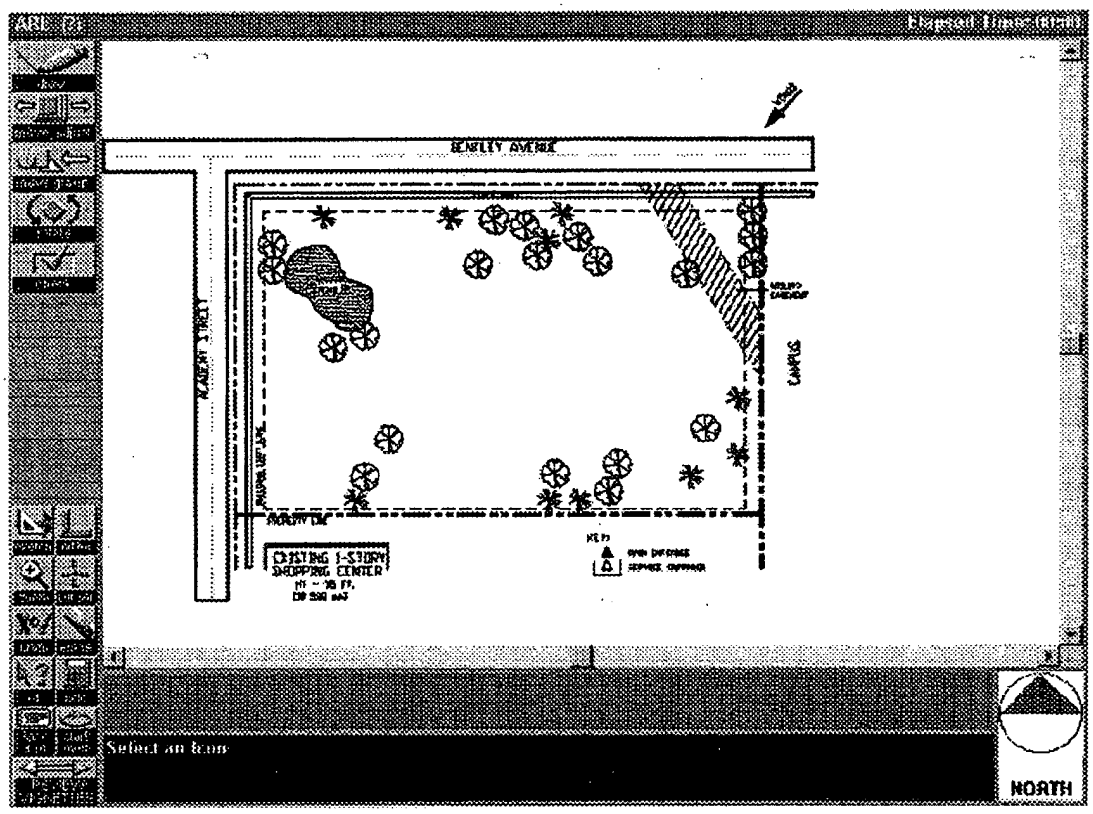

BEASLEY AVENUE
ACADEMY STREET
CAMPUS
EXISTING 1-STORY
SHOPPING CENTER
Select an Item
NORTH

FIG. 65

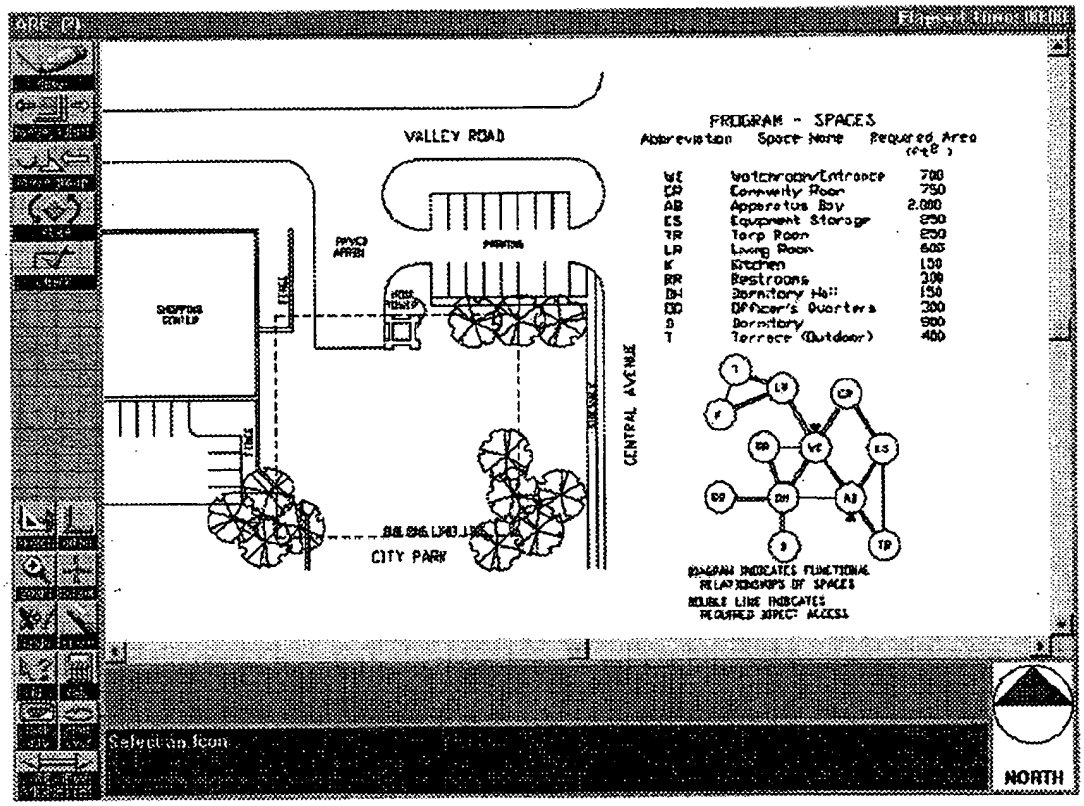

VALLEY ROAD
CENTRAL AVENUE
CITY PARK
PROGRAM - SPACES
Abbreviation Space Name Required Area (ft²)
WC Watercloset/Entrance 700
CR Community Room 750
AB Apparatus Bay 2,000
ES Equipment Storage 950
TR Torp Room 200
LR Living Room 600
K Kitchen 150
RR Restrooms 300
DH Dormitory Hall 150
OQ Officer's Quarters 300
D Dormitory 900
T Terrace (Outdoor) 400
Selection Icon
NORTH

FIG. 66

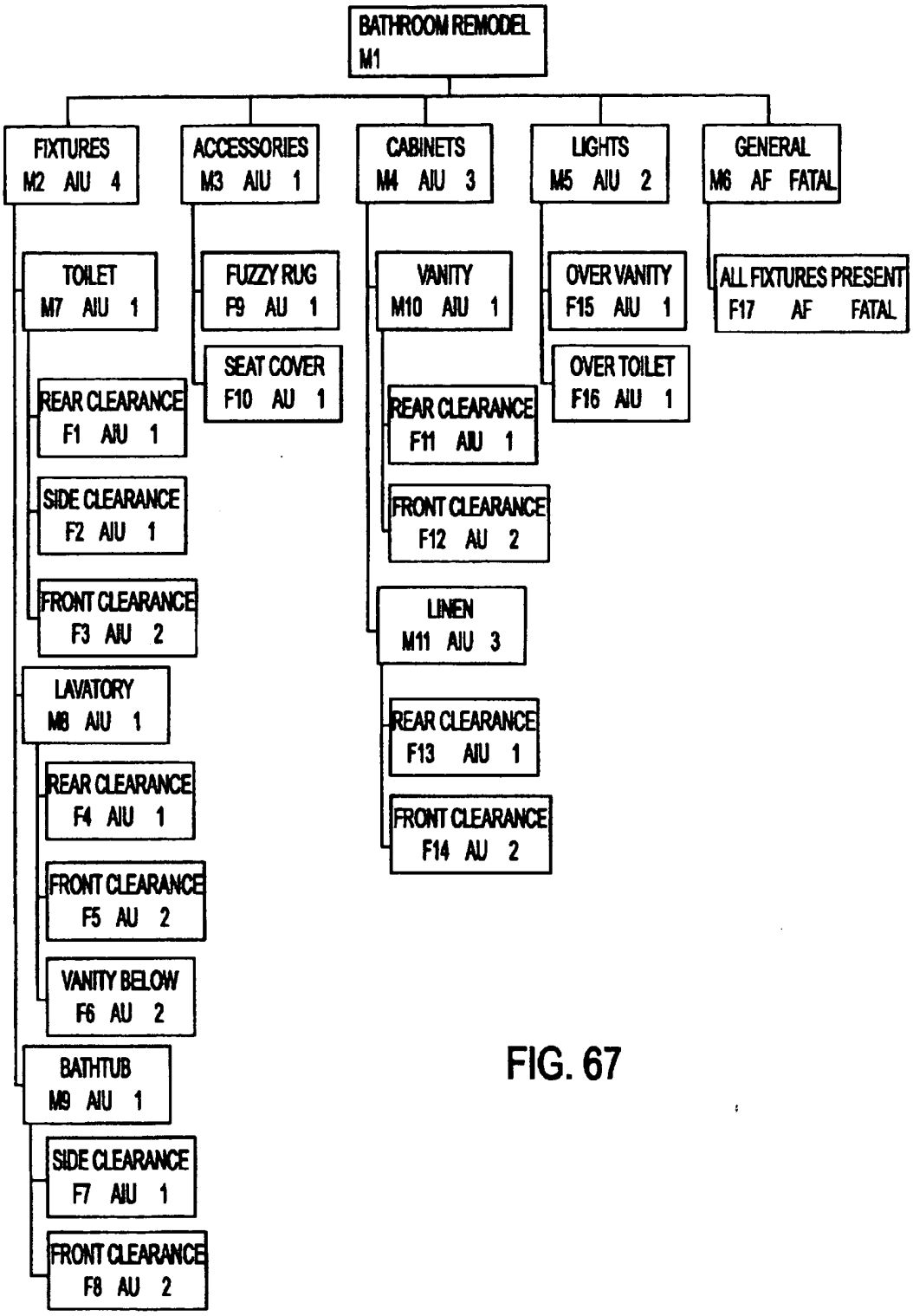

BATHROOM REMODEL
M1
FIXTURES
M2 AIU 4
ACCESSORIES
M3 AIU 1
CABINETS
M4 AIU 3
LIGHTS
M5 AIU 2
GENERAL
M6 AF FATAL
TOILET
M7 AIU 1
REAR CLEARANCE
F1 AIU 1
SIDE CLEARANCE
F2 AIU 1
FRONT CLEARANCE
F3 AIU 2
LAVATORY
M8 AIU 1
REAR CLEARANCE
F4 AIU 1
FRONT CLEARANCE
F5 AU 2
VANITY BELOW
F6 AU 2
BATHTUB
M9 AIU 1
SIDE CLEARANCE
F7 AIU 1
FRONT CLEARANCE
F8 AU 2
FUZZY RUG
F9 AU 1
SEAT COVER
F10 AU 1
VANITY
M10 AIU 1
REAR CLEARANCE
F11 AIU 1
FRONT CLEARANCE
F12 AU 2
LINEN
M11 AIU 3
REAR CLEARANCE
F13 AIU 1
FRONT CLEARANCE
F14 AU 2
OVER VANITY
F15 AIU 1
OVER TOILET
F16 AIU 1
ALL FIXTURES PRESENT
F17 AF FATAL

FIG. 67

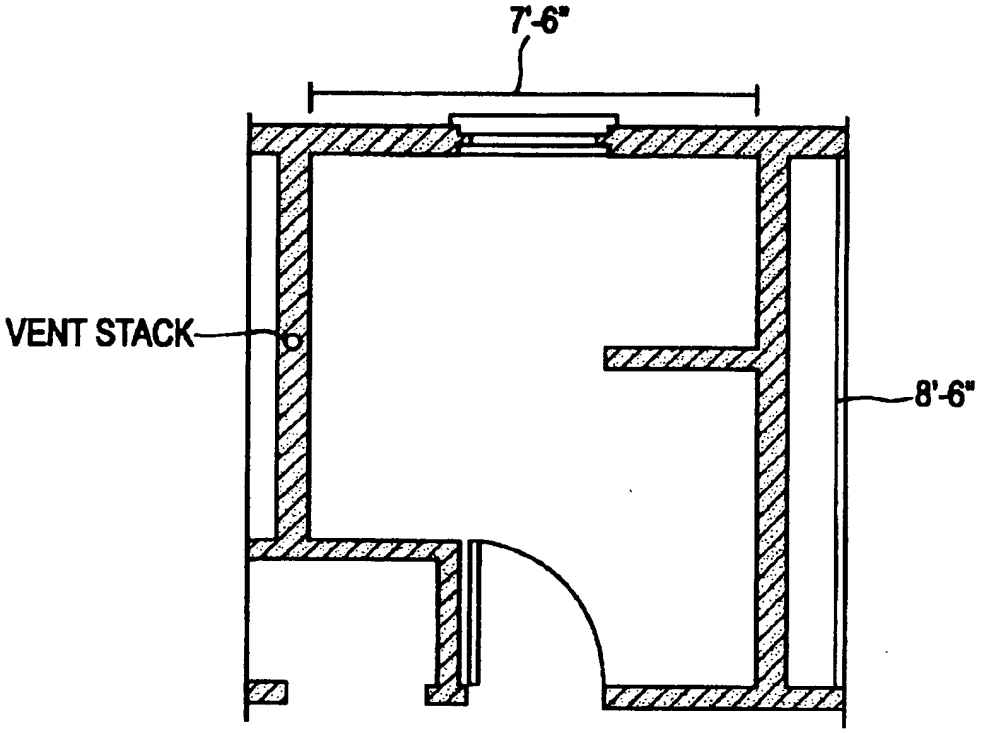


FIG. 68

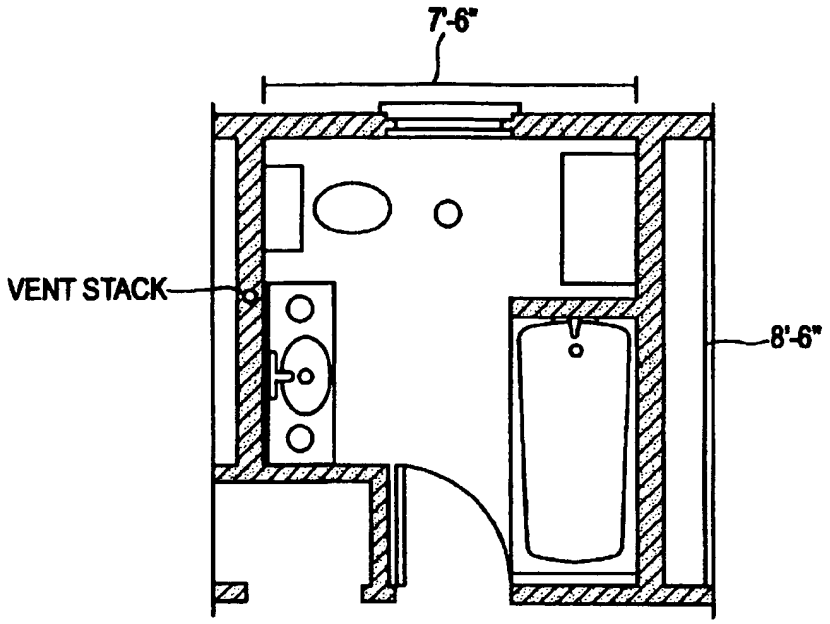


FIG. 69

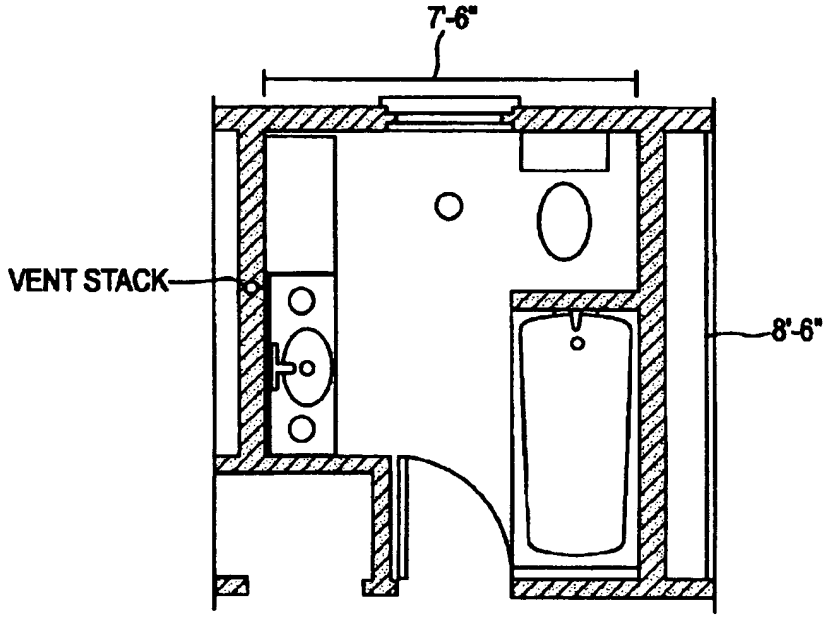


FIG. 70

COMPUTER-BASED SIMULATION EXAMINATION OF ARCHITECTURAL PRACTICE

TABLE OF CONTENTS

C607a.aut
Spaces
Doors
Tags
GrabBar
InfantChangingTable
Lavatory
ALavatory
AShower
Urinal
AUrinal
WaterCloset
AWaterCloset

VIEW SOURCE CODE

View.h
View.cpp

SETBACKS SOURCE CODE

Lot.cpp
Lot.h
Scfilter.cpp
Scfilter.h
Site.cpp
Site.h

SITE GRADING VIGNETTE SOLUTION SOURCE CODE

Features Directory
ALLFEAT.CPP
ALLFEAT.H
B3FTDICT.CPP
B3FTDICT.H
SCFILTER.CPP
SCFILTER.H
FILTAB Directory
FILTAB.CPP
TEST.CPP
Q Directory
BUG.CPP
BUG.H
COVER.CPP
COVER.H
PRIMOBJ.CPP
PRIMOBJ.H
QDATA.CPP
QDO.CPP
QDO.H
QPOINTS.CPP
QPOINTS.H
QTEST.CPP
RAIN.CPP
RAIN.H
SYSHEAD.H
VIOLATE.CPP
VIOLATE.H
Root Directory
B3DRES.H
B3S.CPP
B3S.DEF
B3S.H
LINK_S.CPP
Solution Directory
AUTDATA.CPP
AUTDATA.H
CONTOUR.CPP
CONTOUR.H
SITE.CPP
SITE.H
B3 Directory
B3S.MTX
FILTAB.CPP
QQQ.H

CLAIMS

ABSTRACT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to computer-based technology in assessment particularly for the licensing and certification of professionals such as architects, civil engineers, aeronautical engineers, mechanical engineers, naval engineers, interior design, landscape design, architectural design, etc. For assessment of architects, the system includes tools and methods for item creation, computer programs for computerized item presentation, and programs for automatically scoring test responses by computer.

The purpose of assessment in licensing and certification is to make accurate and reliable decisions as to whether a candidate has met certain standards of competent performance, ordinarily involving a range of higher order cognitive skills as well as the mastery of an extensive knowledge base.

The National Council of Architectural Registration Boards (NCARB) each year prepares the Architecture Registration Exam (ARE) to register entry-level candidates for the practice of architecture. This registration examination is used by 55 member jurisdictions and most Canadian provinces as the basis for initial licensure and reciprocity. The goal of the Architecture Registration Exam is to ensure that only architectural candidates proven to meet a competency level established to protect the health safety and welfare of the public are allowed to practice in the profession.

In the past, the examination consisted of several multiple-choice tests and graphics tests administered annually over a four-day period, with the graphics tests administered one additional time each year. The core functions of architectural practice, namely, site design and building design, are accorded fundamental importance in the graphics tests. Since the purpose of the examination is to protect the public's health safety and welfare, the component tests focus on essential elements of competent practice, rather than on areas like aesthetics of design. Nonetheless, candidates have some opportunity to display creativity by accomplishing tasks requiring problem-solving under constraints.

2. Description of Related Art

While the ARE was originally entirely a paper-and-pencil based test, recently multiple-choice parts of the examination have been administered by computer in a format patented by Educational Testing Service, inventors' assignee, and called Computerized Mastery Testing. That patent, U.S. Pat. No. 5,059,127, entitled COMPUTERIZED MASTERY TESTING SYSTEM, A COMPUTER ADMINISTERED VARIABLE LENGTH SEQUENTIAL TESTING SYSTEM FOR MAKING PASS/FAIL DECISIONS, is hereby incorporated herein.

In the paper-and-pencil implementation of the building design graphics test, a candidate for registration spends 12 hours developing plans and drawing related sections and

elevations. The output of this paper-and-pencil test is a pad of four drawings. Over a hundred architect/jurors meet for three days twice a year to grade these drawings using a holistic grading process.

While in the paper-and-pencil implementation of the site design graphics test, a candidate spends two and three-quarters hours developing solutions to site design vignettes. These drawings are also graded holistically in sessions twice a year involving nearly seventy additional architect/jurors. Figural Response.

The present invention is different from another testing methodology called "figural response" invented and patented by applicants' assignee Education Testing Service. See, e.g., U.S. Pat. No. 5,011,413, entitled MACHINE-INTERPRETABLE FIGURAL RESPONSE TESTING.

Figural response requires the candidate to respond to a graphic question or problem presented on a video display, by drawing lines or other simple geometric figures, positioning arrows or other markers on the graphic, or repositioning elements of the graphic, etc. While figural response may appear to be similar to the simulation methodology of the present invention, differs in many respects—some of which follow. The tasks required of the candidate in figural response were necessarily simpler resulting in problems of a relatively limited nature with but one correct answer for each figural response item.

Figural response relies on bitmap graphics; the present invention relies on a completely different method of image representation called vector graphics. Two main benefits of a vector based approach to graphics are that all the things shown on the screen to the candidate are represented as discrete and insular "objects" inside the computer, rather than as mere regions of a bitmap. A vector/object approach makes building a rich and complex scoring system a much less arduous task. Similarly, a vector/object approach makes the creation of new objects much easier to do.

Though both tests are graphical in presentation the nature of the tasks required by the test taker are very different. Figural response required the test taker to use a mouse to select one of several pictures, or to draw a line connecting two related images. Each figural response item has a single correct answer. The present invention asks the candidate to construct a complete architectural drawing on a nearly blank background. Because of the level of detail allowed, and a conscious effort on the part of the developers to allow for individual style and creativity, there can be an infinite number of equally valid solutions to most of the ARE items.

The figural response items were limited to fixed screen sizes whereas the items of the present invention can be used at any resolution from 480x600 on up. This is because vector images can scale themselves to fit various screen or area requirements much more easily than bitmaps can.

Finally, although figural response items are scored by computer the scoring programs are much simpler because the tasks required of the candidate were much simpler. The simplicity of the task also means that there is only one correct answer to a figural response question, as noted above. Despite that simplicity, there was very little reuse of code across figural response scoring programs; every item needed its own scoring program. The present invention uses the same code for an entire vignette item family. Currently a vignette family may consist of twenty-four individual items which are equivalent in difficulty and the skills tested. Difficulties with prior art methods.

There are several inherent difficulties with the ARE's paper-and-pencil method of test administration. In particular, the paper-and-pencil ARE could only be scheduled infrequently—twice a year. Many weeks were needed for scores to be reported to candidates because of the time required to plan and host a "convention-style" grading where many human graders were flown into a central grading location.

The paper and pencil ARE exams were scored in large convention style settings. Such gradings involve finding skilled architects who can take time off from their work to serve as graders, transporting them to a central location, making hotel arrangements for all the people involved, and hiring and training temporary clerical staff to manage a large volume of secure paper.

Humans grade less consistently than computers and are harder to monitor. Human grades rely on a gross holistic view of a solution which incorporates much less detail and precision than computer scores.

Computer generated ratings may be superior to human scores because testing experts and experts skilled in the art of architecture can manipulate the relative impact that each feature of a solution that is analyzed has on the solution's final score.

SUMMARY OF THE INVENTION

The present invention provides a computer-based method and system for competency level assessment of professionals such as architects and engineers. The invention also provides a new computer-based simulation of architectural practice. The system can replace and/or complement paper-and-pencil professional assessments. The system of the present invention provides for computer-based delivery and scoring of the examination.

One preferred embodiment of the present invention provides a fully computer-administered and computer-automated scoring of open-ended computer-based simulations corresponding to the earlier two "graphic" or open-ended questions covering Building Design and Site Design of the ARE examination. This preferred embodiment of the present invention assesses, in a realistic setting, the higher-order skills considered essential to the competent practice of architecture, and in particular, the aspects of site and building design.

The testing system of one preferred embodiment of the present invention comprises three distinct functional subsystems—authoring, delivery and scoring.

The authoring subsystem provides the functionality required to "author" or create and establish scoring rules and criteria for the test items, that is, particular vignettes. It allows the test creator to specify the names and attributes of spaces that will comprise a unique script. These attributes consist of conditions that are internal to the space itself and which are to be met by the candidate.

The delivery subsystem assembles a complete test item for a candidate based on instructions stored in the authoring (".aut") file which tells the delivery subsystem to reference various files stored in multiple formats and locations and how to present certain features, options, menus, and drawing elements to the candidate. One preferred embodiment of the delivery subsystem relies on item Framework software which has been compiled as a dynamic link library (".dll" file) and which includes a large library of computer code representing geometric objects that are referenced in current and foreseeable test items, this code may be reused, in whole or part, for future test items. The preferred embodiment of the delivery subsystem of the present invention interfaces with ETS's OPEN SYSTEMS ARCHITECTURE (OSA) test administration system which provides many of the

administrative capabilities of the present invention. ETS has a patent directed to among other things, computer systems and methods which include OSA capabilities, it is U.S. Pat. No. 5,565,316, "SYSTEM AND METHOD FOR COMPUTER BASED TESTING" which is hereby incorporated herein.

In order to score a vignette, the candidate's solution must be decomposed and then analyzed so a score can be assigned. Decomposition is another way of saying that the graphic response of the candidate is represented in mathematical terms suitable for analysis. Additionally, the scoring method relies on a knowledge elicitation and representation approach developed by one of the co-inventors of the present invention. The method produces a treelike or hierarchical organization of problem features needed to characterize performance on a problem class or vignette type.

There are basically two types of nodes in the scoring tree hierarchy. One type consists of low-level features requiring a direct computation from the solution, such as computing the location of an element, the distance between design elements, or counting the presence or absence or some elements. The second type of node consists of clusters of lower-level features. All possible values for a cluster can be represented by a two-dimensional matrix. The matrix approach to summarize scores is a convenient format to rank the feature cluster measures, and locate tuples to identify the combinations associated with a particular score.

After the vignette is scored it is sent along with information about the test item, the answer and the test taker to a back end process which combines the individual vignette scores and issues a score report for the test taker.

ADVANTAGES OF THE PRESENT INVENTION

The computer interface of the present invention is powerful and easy to learn, and yet consistent across different types of vignettes.

Because of the design of the computer interface of the present invention, the speed with which a candidate renders a solution to a particular vignette is increased, which permits either a shorter testing period or more vignettes to be administered in the same period of time. An increase in the number of vignettes permits sampling of a wider variety of skills than previously possible.

Other advantages of the computer-based testing of the present invention includes accuracy, consistency and quick turn-around time.

It is an object of the present invention to provide a computer-based system for assessment purposes, in whole or in part, of professionals and more particularly in the licensing and certification of architects.

It is an object of the present invention to provide an examination for assessing professionals for licensure or certification which has computer-based simulations which realistically simulate problems in architectural planning and design.

It is a further object of the present invention to provide for scoring of the computer-based simulations by computer algorithms that do not require further hand scoring by experts, except as a quality control procedure.

BRIEF DESCRIPTIONS OF THE DRAWINGS

FIG. 1 shows a flowchart of one preferred embodiment of the present invention.

FIG. 2 shows the display screen for the Schematic Design Vignette of a preferred embodiment of the present invention.

FIG. 3 shows the display screen, for the Schematic Design Vignette of a preferred embodiment of the present invention, after the Sketch Icon Tool has been selected.

FIG. 4 shows the display screen, for the Schematic Design Vignette of a preferred embodiment of the present invention, after the Draw Icon Tool has been selected.

FIG. 5 shows the display screen, for the Schematic Design Vignette of a preferred embodiment of the present invention, where, first, the Draw Icon Tool has been selected and second, the Door entry on the Draw menu has been selected.

FIG. 6 shows the display screen for the Schematic Structural Design Vignette of a preferred embodiment of the present invention.

FIG. 7 shows the display screen for the Mechanical and Electrical Plan Vignette of a preferred embodiment of the present invention.

FIG. 8 shows the display screen for the Building Section Vignette of a preferred embodiment of the present invention.

FIG. 9 shows the display screen for the Accessibility—Ramp Vignette of a preferred embodiment of the present invention.

FIG. 10 shows the display screen for the Accessibility—Toilet Room Vignette of a preferred embodiment of the present invention.

FIG. 11 shows the computer scoring decision tree for the Accessibility—Toilet Room Vignette of one preferred embodiment of the present invention.

FIGS. 12–34 show several of the Features, including A, I and U scoring, for the Accessibility—Toilet Room Vignette of one preferred embodiment of the present invention.

FIG. 35 shows the Master Features Matrix for the Accessibility—Toilet Room Vignette of one preferred embodiment of the present invention.

FIG. 36 shows the Entry Door Features matrix for the Accessibility—Toilet Room Vignette of one preferred embodiment of the present invention.

FIG. 37 shows the Handicapped Fixtures Features matrix for the Accessibility—Toilet Room Vignette of one preferred embodiment of the present invention.

FIG. 38 shows the Grab Bar Features matrix for the Accessibility—Toilet Room Vignette of one preferred embodiment of the present invention.

FIG. 39 shows the Other Fixtures Features matrix for the Accessibility—Toilet Room Vignette of one preferred embodiment of the present invention.

FIG. 40 shows the Travel Path Features matrix for the Accessibility—Toilet Room Vignette of one preferred embodiment of the present invention.

FIG. 41 shows the Design Logic Features matrix for the Accessibility—Toilet Room Vignette of one preferred embodiment of the present invention.

FIG. 42 shows the directions for drawing the 4" wall for the Accessibility—Toilet Room Vignette.

FIG. 43 shows the display screen for the Stair Design Vignette of a preferred embodiment of the present invention.

FIG. 44 shows the display screen for the Roof Plan Vignette of a preferred embodiment of the present invention.

FIG. 45 shows the display screen for Interior Layout Vignette of a preferred embodiment of the present invention.

FIG. 46 shows the display screen for the Site Section Vignette of a preferred embodiment of the present invention.

FIG. 47 shows the index screen for the Site Section Vignette of a preferred embodiment of the present invention.

FIG. **48** shows the vignette directions screen for the Site Section Vignette of a preferred embodiment of the present invention.

FIG. **49** shows the program screen for the Site Section Vignette of a preferred embodiment of the present invention.

FIG. **50** shows the tips screen for the Site Section Vignette of a preferred embodiment of the present invention.

FIGS. **51**(*a*) and **51**(*b*) show the general test directions screen for the Site Section Vignette of a preferred embodiment of the present invention.

FIG. **52** shows the display screen for the Site Analysis Vignette of a preferred embodiment of the present invention.

FIG. **53** shows the display screen for the Site Grading Vignette of a preferred embodiment of the present invention.

FIG. **54** shows the vignette directions screen for the Site Grading Vignette of a preferred embodiment of the present invention.

FIG. **55** shows the program screen for the Site Grading Vignette of a preferred embodiment of the present invention.

FIG. **56** shows the tips screen for the Site Grading Vignette of a preferred embodiment of the present invention.

FIG. **57** shows the computer scoring decision tree for the Site Grading Vignette of a preferred embodiment of the present invention.

FIGS. **58**–**61** show several of the features, including A, U and F scoring, for the Site Grading Vignette of a preferred embodiment of the present invention.

FIG. **62** shows the features matrix for the Site Grading Vignette of a preferred embodiment of the present invention.

FIG. **63** shows the display screen for the Zoning Section Vignette of a preferred embodiment of the present invention.

FIG. **64** shows the display screen for the Site Parking Vignette of a preferred embodiment of the present invention.

FIG. **65** shows the display screen for the Site Design Vignette of a preferred embodiment of the present invention.

FIG. **66** shows the display screen for the Block Diagram Vignette of a preferred embodiment of the present invention.

FIG. **67** shows the scoring tree or feature evaluation map for the hypothetical bath remodeling vignette.

FIG. **68** shows the initial bathroom display for the Hypothetical Bathroom Remodel Vignette.

FIG. **69** shows a good solution to the Hypothetical Bathroom Remodel Vignette design problem.

FIG. **70** shows a not so good solution to the Hypothetical Bathroom Remodel Vignette design problem.

DETAILED SUMMARY OF THE INVENTION

The present invention comprises a test delivery system and an automated scoring system. As described below, the test delivery system is divided between the platform, i.e., computer hardware and computer operating system and the interface presented to the candidate, i.e., the common and unique tools provided to the candidate, with which to answer the test assignments. See, FIG. 1

PLATFORM AND THIRD PARTY SOFTWARE

The delivery system for one preferred embodiment of the present invention comprises the following equipment. An Intel Corporation 80486 cpu (or better) based personal computer, with video display device (monitor), keyboard and mouse. Generally, a minimum of 8 megabytes of RAM, though the actual amount of memory required is dependent upon the operating system. Either Microsoft Windows 3.1 or Windows 3.11 running with Win32s 32 bit extension or Microsoft Windows 95, or Windows NT. Educational Testing Service's OSA scientific calculator.

AutoCAD® OEM distributed by Autodesk, Inc., 111 McInnis Parkway, San Rafael, Calif. 94903, USA. AutoCADO OEM is a computer-aided design (CAD) engine for third-party developers. It is built from AutoCAD® Release 12. It provides the foundation for new applications that require DWG compatibility. AutoCAD® OEM Release 2 lets developers and CAD managers use an OEM version of AutoCAD®, to create, industry-specific applications.

Microsoft's MediaView help screen viewer.

Rogue WaveTools.h++ version 5.2 by Rogue Wave Software.

Invention Not Limited to Particular Vignettes

While the descriptions of the embodiments of the present invention given below are generally disclosed in terms of one or another specific vignette, the present invention is not limited to the disclosed vignettes and one ordinarily skilled in the art will have no difficulty applying the disclosures to any number of different vignettes.

AUTHORING SUBSYSTEM

As the name suggests, the authoring subsystem provides the functionality required to "author" or create and establish scoring rules and criteria for the test items, that is, particular vignettes. It allows the test creator to specify the names and attributes of spaces that will comprise a unique script. These attributes consist of conditions that are internal to the space itself and which are to be met by the candidate. One example is square feet. The program, that is, the instruction to the candidate as to what the candidate is required to accomplish with respect to a particular vignette, may call for a space to be drawn with an area of a certain square feet. The authoring file will contain this space requirement, which will in turn be used by the scoring subsystem to check whether or not this program condition has been met. See, for example, the "SAMPLE AUTHORING FILE FOR THE ACCESSIBILITY-TOILET VIGNETTE" in the Source Code Appendix.

A primary function of authoring is that the drawings are used for a database of geometric information, the ".aut" files are used to reference this information, and provide additional information about how these geometric objects must relate to one another in a particular script. The ".aut" file, therefore, is a database of all non-geometrical information.

The scoring authoring subsystem may specify direct access and primary adjacency (for example, the inter-space relationships called for by the program), or relationships of spaces to site amenities (for example, a kitchen may need access to an alley so that deliveries can be made, and trash can be picked up).

"View" is another feature that the scoring subsystem may be required to extract from the authoring file. That is, a room may need a view of a site feature, and the fact that the candidates' instructional program calls for this relationship to exist would require the authoring subsystem to define certain parameters that are used in the scoring program's "view" formula. For instance, whether or not the view requirement has been met may depend on the distance of the room from the site feature, the angle of the side of the room containing a window with relation to the site feature, and how many other objects, and of what type, may be placed between the room and site feature before an otherwise valid view is considered obscured. All of these, and similar variables, are placed in the scoring authoring file. Because they have been stored outside the compiled code in a file that can be edited with any word processor, scoring tolerances

can be altered quickly and easily without any re-writing or recompiling of computer code.

While the site amenities and site features mentioned are, in one preferred embodiment, displayed to the candidate in the form of a AutoCad® ".dwg" format, that format will not generally suffice to show all the underlying representations that may be needed. Therefore, the authoring subsystem provides means for creating these entities, capturing, specifying and detailing their attributes, which will include graphical and positional data, as well as attributes describing their transparency or opaqueness, their ability to enable or prevent pedestrian or vehicular access, and other parameters required by the delivery or scoring subsystem, or both.

Finally, the authoring subsystem has the ability to bundle all of this information along with all of the necessary supporting documentation (drawings, documents) etc. that are used on the "reference screen", and pass this information along to the delivery and scoring subsystems.

DELIVERY SUBSYSTEM

The delivery subsystem assembles a complete test item for a candidate based on instructions stored in the authoring (".aut") file which tells the delivery subsystem to reference various files stored in multiple formats and locations and how to present certain features, options, menus, and drawing elements to the candidate.

For example, an ".aut" file may contain a reference to the relevant site background drawing and a list of those tools which are specific to the test item will be available on the tool bar. It may also contain references to the location of item specific code libraries that may be external to the main executing program.

The primary function of this process is to allow the candidate to create a solution that will satisfy programmatic, code and design logic considerations. Therefore, this subsystem provides the candidate with the ability to draw spaces, and detail like doors, windows, and wall openings, and place elevators and stairs. Importantly, this subsystem offers the candidate the ability to draw the spaces that the script calls for.

In one preferred embodiment of the present invention, this subsystem for the schematic design type vignette (see, e.g., FIG. 2) provides the candidate with the ability to draw on a background image that shows the site, the buildable area, and the site amenities and features that they will have to consider in creating a solution. See the other displays screen figures for additional site amenities and features.

In the schematic design type vignette embodiment, the delivery subsystem also provides the candidate with the ability to zoom and pan, to move spaces and detail, to measure and to sketch, and to erase. The candidate can also work on more than one layer, in which case, he/she can view each layer separately or view an alternate layer in a manner (for example, a light color grey) which will allow it to be used by the candidate as a template. One kind of layer which can be viewed in this manner is a floor.

In the preferred embodiment of the present invention the candidate can not modify the background image. The delivery subsystem of this embodiment also provides the candidate with the ability to show or not to show a grid, to change cursors, to hide or show the site, or to hide or show alternate floors.

The delivery subsystem has the capability of limiting the actions a candidate may take. For example, as required by the particular script, the system may limit doors, windows and wall openings from being placed anywhere except within a wall.

The delivery system is not limited to the above capabilities. It is designed to be able to be modified to add capabilities as needed.

FRAMEWORK

The preferred embodiment of the present invention has item Framework software which has been compiled as a a Windows ® dynamic link library (".dll" file) and which includes a large library of computer code representing geometric objects that are referenced in current and foreseeable test items, this code may be reused, in whole or part, for future test items. Therefore, a typical vignette program requires very little additional code beyond that which is available in the Framework. The dll file provides a set of programs that are available to applications at run time.

One benefit in using the Framework of the present invention is that an interface function may have multiple uses. In one vignette it may check overlaps by examining the position of two vector polygons designated as "rooms" in that vignette's authoring file. While in another vignette that same interface function may be examining the position of polygons which represent two angled roof planes or a sidewalk that is required to be adjacent to, but obviously not inside, a building. This function was created to avoid penalizing candidates who may be uneasy with a computer mouse but who nevertheless attempted to position a required element with the correct relationship to another site or solution object.

The Framework file directory for one preferred embodiment of the present invention includes the following subdirectories: RESOURCE; COMPONEN; CONTROLS; DWG; EVENTS; FEATURES; GEOMETRY; GRAPHICS; HDR; MOUSETRK; OBJS; OSA; OSACALC; PERSTGEO; APPLICAT; SCORING; TRANSACT; VGNOBJEC; VGNTASKS; VGNWIND; and WINDOWS. While the function of the files found in a particular subdirectory may be obvious from the subdirectory's name, nevertheless a brief description follows.

Framework Software Directories For One Preferred Embodiment

RESOURCE <DIR> Windows Resource file includes BITMAPS, DIALOGS, and the STRINGTABLE containing Help Messages displayed on screen.

COMPONEN <DIR> Object components—bags, sets, nvtree code.

CONTROLS <DIR> Standard controls code for handling buttons, bitmaps.

DWG <DIR> Interfaces with AutoCADO OEM computer-aided design (CAD) engine.

EVENTS <DIR> Code to handle all mouse and keyboard events.

FEATURES <DIR> Code to do feature extraction for Scoring.

GEOMETRY <DIR> Geometry objects—includes points, lines, circles, rectangles.

GRAPHICS <DIR> Code to draw all the graphics to the screen.

HDR <DIR> Contains the definitions for pre-compiled headers.

MOUSETRK <DIR> DLL code to track mouse movement between windows.

OBJS <DIR> Object files created during compilation.

OSA <DIR> Messages used to communicate with OSA during administration.

OSACALC <DIR> OSA code for the on-screen calculator.

PERSTGEO <DIR> Persistent Geometry code for saving objects to disk.

APPLICAT <DIR> Vignette application main loop code.

SCORING <DIR> Scoring code to process matrix file and feature dictionary.

TRANSACT <DIR> Code to process all candidate screen transactions to allow UNDO/REDO capability.

VGNOBJEC <DIR> Objects common to all vignettes include sketch objects, full screen cursor, DWG objects.

VGNTASKS <DIR> Tasks common to all vignettes include the drawing of sketch objects, rotating, measuring, zooming, moving, identifying, selecting, erasing.

VGNWIND <DIR> Defines all the windows common to all vignettes.

WINDOWS <DIR> Code to interact with specific MicroSoft Windows® features, such as changing the cursor, accessing the timer, extracting information from the .INI file, and starting up a process.

A typical test item may rely on the Framework for 80% of its functionality and on new code for only about 20%. Framework includes a large library of computer code representing geometric objects that are referenced in current and many foreseeable test items. For example, the following functionality is available in one preferred embodiment:

1. Objects that are drawn by the candidate—lines, polygons, polylines, circles, etc.

2. Objects that are placed by the candidate—"dwg objects", which are vector objects that can be anything.

3. "Existing objects"—objects that are part of the background drawing, but whose whereabouts and properties need to be known by delivery (and/or scoring). These can be simple or complex geometric objects.

Use of the Framework has a positive impact on the process of item creation because item creators can rely on the library of pre-existing objects to use in creating a future item. Such items include architectural object definitions, such as-object sizes, object scales, object colors and object default orientations. OSA

The preferred embodiment of the delivery subsystem of the present invention interfaces with ETS's OSA system which provides many of the administrative capabilities of the present invention. While the preferred embodiment utilizes ETS's OSA system, there are commercially available computer programs with enough functionality to generally practice the administrative functions provided by OSA for the present invention. One example is Sylvan's Administrative System.

The preferred embodiment of the delivery subsystem is designed to be interoperable with OSA, and could probably be made so with other test administration computer systems. Additionally, this preferred embodiment has the capability of compressing the candidate's solution with reference to the script and passing this to OSA.

INTERFACE

Description of Common Tools

Common tools provide the candidate with a method for sketching various lines, curves and geometric objects. Geometric objects created with these are not considered in determining a candidate's score. Clicks refer to depressing and releasing one of the mouse buttons or if a pointer is being used, the key/bar used in conjunction with the pointer. In one embodiment of the present invention the tools appear on the left hand side of the display screen. See FIG. 3.

Sketch Icon Tools.

The candidate can access the following drawing aid tools by selecting the icon entitled "sketch", which activates the "Sketch Tools" tool bar as shown in FIG. 4. See also FIG. 5.

VIEW GRID/HIDE GRID: Displays and hides light gray grid (not always available).

HIDE SKETCH ELEMENTS: Toggles sketch layer elements on/off.

MEASURE: Gives the candidate the ability to measure distances, by clicking on 2 points (click to specify start and end points), in either feet and inches or meters, depending upon which system of measurement is being employed in the particular examination.

LINE: Draws sketch lines by clicking to specify the start and endpoints of the line.

CIRCLE: Draws circles by clicking to specify the center of the circle, then another click to specify the radius.

ORTHO Icon Tool.

The orthogonal tool forces all lines or polylines to be drawn horizontally or vertically, but not diagonally.

ZOOM Icon Tool.

When the candidate has selected the ZOOM icon tool, he/she can then select an area of the screen he/she wants to magnify by clicking once on the drawing to specify the start point, and clicking a second time to specify the end point of the zoom box. The magnification of the zoom depends on the size of the zoom box. A smaller box gives the candidate greater magnification than a larger box.

CURSOR Icon Tool.

The candidate by selecting the cursor icon tool can toggle between an AutoCAD®-style cross-hair cursor and a small cursor.

UNDO Icon Tool.

Clicking on this icon allows the candidate to undo the last change they made to their solution. Clicking a second time restores the last change.

ERASE Icon Tool.

The candidate selects this icon, then selects a drawn or placed object(s), by clicking on the erase icon tool again the object(s) are erased.

ID Icon Tool.

The Id icon tool when selected displays the name and/or the dimensions of all placed and drawn objects. The candidate selects this icon, then selects a drawn or placed object. The requested information will be display in the Information Window.

CALC Icon Tool.

When the candidate selects the Calc or calculator icon tool, a calculator is displayed on the screen. The displayed calculator performs the mathematical calculations necessary to respond to the requested task. Such functions include sine, cosine, tangent, arcsine, arccosine, arctangent, etc.

TASK INFO Icon Tool.

Selection of the Task Info icon tool, enables the candidate to toggle back to the Task Information screen discussed below. It functions the same as hitting the spacebar.

Start Over Icon Tool.

Selecting the start over icon tool clears the drawing completely and allows the candidate to begin anew.

REVIEW Icon Tool.

The Review icon tool has two functions, it is used first, to both exit out of the vignette and proceed to the next test vignette, if any, and second, to review a prior vignette. (Another embodiment of the present invention uses a "Done" icon tool which only permits the first function.) If the candidate selects the Review icon tool once, the message in Information Window provides the candidate with a sec-

ond chance to stay in the vignette by selecting any other icon, or to click on the Review icon tool again to exit to the next vignette or from the examination.

Description of Unique Tools

The following tools appear on one or more vignettes and each of the tools listed below can be found in various combinations throughout all vignettes. See FIG. 3.

CHECK Icon Tool.

Selecting this icon brings up a menu of options that may include:

CHECK OVERLAPS:

This tool is used to detect any overlapping elements, for those vignettes which allow for this check. Since some vignettes allow the candidate to provide a response with overlapping elements, in one preferred embodiment this tool would not be available on those vignettes. In one preferred embodiment, overlapping elements appear in pink.

CHECK CUT TREES:

When elements are placed over existing trees, the trees are flagged as "cut trees" when this icon is selected.

DRAW Icon Tool.

Selecting this icon brings up a menu that displays lists and sub-lists of items to be placed or drawn, such as buildings, trees, roads, grades, parking spaces, rooms, etc. In the preferred embodiment of the present invention, this tool is available except for B3 Grading (see FIG. B3).

MOVE,ADJUST Icon Tool.

This tool is used to move and adjust placed or drawn objects. The candidate selects this icon, if he/she clicks while the cursor is on an edge of a drawn object and drags the cursor across the screen, the size of the object will adjust accordingly. But if the candidate selects this icon, then clicks when the cursor is within the object and drags the cursor across the screen, it will move the drawn or placed object as a whole.

MOVE GROUP Icon Tool.

This tool allows the candidate to move more than one placed or drawn object at a time, while retaining their alignment and placement. The candidate selects this icon, then click on the objects he/she wants to move, then clicks on Move Group again to move them.

ROTATE Icon Tool.

This tool is used to rotate placed or drawn objects. In one preferred embodiment of the present invention, the tool rotates some objects in 90-degree increments; rotates others in 15-degree increments.

LAYERS Icon Tool.

Selecting this icon brings up a menu that lists the various layers of information that can be turned on/off, that is, displayed or not displayed. Options on this menu are variable with each vignette and may include:

HIDE BUILDABLE AREA:

This allows the candidate to temporarily hide a buildable area that he/she drew.

HIDE SECONDARY CONSTRUCTION AREA:

This allows the candidate to temporarily hide a secondary construction area.

HIDE SITE:

Hides entire base drawing.

HIDE OTHER FLOOR:

Hides either floor 1 or floor 2.

SET ROOF Icon Tool.

This icon tool allows the candidate to define a roof plane by setting slope direction, slope ratio, elevation vertex, and elevation value. This icon is selected after plane is drawn. The following features are available after the "Set Roof" icon is selected:

Slope Direction: "The way the water falls." The arrow points in the direction the roof plane slopes. To set slope direction, the candidate clicks on Set Roof, then clicks on slope arrow until desired direction is achieved. In one preferred embodiment, each click rotates arrow 45 degrees. Slope Ratio: Rise:Run. This ratio defines the height that the roof plane will rise, per specified horizontal distance across. To set the slope ratio, the candidate clicks directly on slope ratio displayed within the plane.

Elevation Vertex: This is the vertex of the plane for which the elevation is assigned. By clicking on any point within the plane (except on slope arrow, ratio or elevation value), the location of the vertex will move clockwise by one vertex.

Elevation Value: Allows setting the elevation of the plane at the elevation marker. This is the height of the plane at a given vertex. The value is entered in feet and inches (when the English system is used), by moving up/down arrows to desired value. To enter value, the candidate clicks on displayed elevation value. Elevations for all other vertices are automatically calculated.

Icons for Another Embodiment

Another embodiment of the present invention has the following icon tools in addition to some or all of the preceeding ones.

DONE Icon Tool.

The DONE icon tool is used to exit out of the vignette and proceed to the next test vignette, if any. If the candidate selects it once, the message in Information Window provides the candidate with a second chance to stay in the vignette by selecting any other icon, or to click on the DONE icon tool again to exit to the next vignette or from the examination.

OPTIONS Icon Tool.

Selecting this icon brings up a menu of options (variable with each vignette) that may include:

1. CHECK OVERLAPS:

Used to check overlapping elements. In one preferred embodiment, overlapping elements appear in pink.

2. CHECK CUT TREES:

When elements are placed over existing trees, the trees are flagged as "cut trees" when this icon is selected.

3. HIDE BUILDABLE AREA:

This allows the candidate to temporarily hide a buildable area that he/she drew.

4. HIDE SECONDARY CONSTRUCTION AREA:

This allows the candidate to temporarily hide a secondary construction area.

5. HIDE SITE:

Hides entire base drawing.

6. HIDE OTHER FLOOR:

Hides either floor 1 or floor 2.

7. SET ROOF:

Allows the candidate to define a roof plane by setting slope direction, slope ratio, elevation vertex, and elevation value. This icon is selected after plane is drawn. The following four (4) features are available after the "Set Roof" icon is selected:

8. Slope Direction: "The way the water falls." The arrow points in the direction the roof plane slopes. To set slope direction, the candidate clicks on Set Roof, then clicks on slope arrow until desired direction is achieved. In one preferred embodiment, each click rotates arrow 45 degrees.

9. Slope Ratio: Rise:Run. This ratio defines the height that the roof plane will rise, per specified horizontal distance

across. To set the slope ratio, the candidate clicks directly on slope ratio displayed within the plane. Elevation Vertex: This is the vertex of the plane for which the elevation is assigned. By clicking on any point within the plane (except on slope arrow, ratio or elevation value), the location of the vertex will move clockwise by one vertex.

10. Elevation Value:

Allows setting the elevation of the plane at the elevation marker. This is the height of the plane at a given vertex. The value is entered in feet and inches (when the English system is used), by moving up/down arrows to desired value. To enter value, the candidate clicks on displayed elevation value. Elevations for all other vertices are automatically calculated.

11. SWITCH FLOORS:

Used to toggle between floors 1 and 2.

12. MOVE ELEVATION MARKER:

Used to move the elevation marker from vertex to vertex.

ROTATE SITE Icon Tool.

This tool is used to rotate the entire site.

ROTATE SKYLIGHT Icon Tool.

This tool is used to rotate a skylight already in place. In one preferred embodiment, it rotates the skylight in 90 degree increments.

VIEWING WINDOWS

Information Window.

The Information Window, is used to inform the candidate of object names, sizes of objects, and distances between objects. It is also used to warns candidates before they carry out potentially destructive commands such as "erase", "start over" and/or "review".

Help Window.

The Help Window is used to inform the candidate of what actions are available at any given time. As the candidate works through interactions that require on or more clicks, the Help Window is updated to inform them what they can do next. In one preferred embodiment of the present invention, it is horizontally oriented along the bottom of the screen.

Work Window.

The Work Window, is the large window in the center of display screen. It shows the initial template picture onto which the candidate enters his or her solution. The initial picture may contain site features that the candidate must take into account when planning his or her solution, including existing trees, roads, protected wetlands, or bordering properties. See for example, FIG. 2.

Task Information Screen.

Selection of the Task Info icon tool, enables the candidate to toggle back to the Task Information Screen. The task information screen provides the name of the vignette as well as links (areas to click on) to the informational screens. Once at an informational screen clicking on the INDEX icon takes the candidate back to the Task Information Screen.

Informational Screens

Vignette Directions Screen.

See, for example, FIG. VIGNETTE DIRECTIONS. Program Screen.

See, for example, FIG. PROGRAM.

Tips Screen.

See, for example, FIG. TIPS.

General Test Directions Screen.

See, for example, FIGS. GENERAL TESTa and GENERAL TESTb.

SOLUTION SCORING SYSTEM

Scoring Method Generally

In one preferred embodiment of the present invention, the test consists of three divisions. Each are composed of three to six vignettes. Each vignette addresses a number of tasks or knowledge skills, and abilities related to building and site design that were identified by a task analysis of the field of architecture. The vignettes of the present invention thoroughly cover the areas designated as most important by the task analysis. In a preferred embodiment of the present invention, each candidate taking a vignette is likely to receive a different problem from a pool of psychometrically equivalent problems.

The site design vignettes look remarkably similar to those found in the paper-and-pencil test. The interface between the candidate and the computer was designed with the computer novice in mind. The candidate may interact with the vignette through the use of a computer mouse or other pointing device or the keyboard. The candidate chooses tools such as "Draw" or "Move" by selecting icons on the computer screen.

The simulations that test skills in building and site design require the availability of many materials, such as programs, codes, drawings, and other resources usually found in an architect's office. The computer-based test of the present invention provides the essential materials to the candidate, as needed, at the click of an icon or the press of the keyboard space bar.

Decomposition.

In order to score a vignette, the candidate's solution must be decomposed and then analyzed so a score can be assigned. Decomposition is another way of saying that the graphic response of the candidate is represented in mathematical terms suitable for analysis.

Decomposition for simulations of the present invention is much different than that for figural response. In figural response the system need only check for the presence of the correct response. Whereas in simulations of the present invention the system must be able to deal with an almost infinite number of responses.

Vignette scoring systems in accordance with the present invention will generally include, depending on the particular vignette and to a greater or lesser extent, the following features, some of which may overlap in functionality. Vignette scoring systems may:

1. Assess completeness of the candidate's response by verifying that the candidate has performed all required operations. This is often done as part of a "fatal flaw" check.
2. Determine grammatical correctness (or design grammar) of the solution by verifying that the candidate has respected all of the vignette's program constraints in the responses. A failure to be grammatically correct will generally constitute a "fatal flaw" and result in an unacceptable score for the vignette.
3. Identify superfluous response components, in those cases where the interface permits superfluous responses, by examining the response of the candidate for unnecessary or ineffective action.
4. Verify satisfaction of the test program by examining the response of the candidate for compliance with the requirements of the vignette.
5. Check technical correctness by assessing the response of the candidate for satisfaction of the technical requirements associated with the vignette, for example, code compliance.
6. Evaluate the efficiency and design logic by determining the level of skill and ability of the candidate as exhibited by the quality and efficiency of the solution.

Scoring Trees.

The scoring method relies on a knowledge elicitation and representation approach developed by one of the co-inventors of the present invention. The method produces a treelike or hierarchical organization of problem features needed to characterize performance on a problem class or vignette type. As an illustration consider the design problem of planning a bathroom displayed in FIG. **10**.

This is what the candidate would see on the computer screen with the icons on the left serving as the interface for the candidate to enter and solve the problem. By pressing the space bar on the computer keyboard or by selecting the Task Info icon the candidate can refer to the problem to be resolved as well as access relevant reference material. Clicking on the Draw icon offers the candidate a menu of design objects that can be placed in the solution, such as a bathtub, toilet, etc. The other icons allow the candidate a series of actions to refine the solution, such as moving and rotating the different design elements.

Scoring trees are formulated initially as a top-down process where the relevant professional, for example, architects, based on their experience grading open-ended problems in the paper-and-pencil test, formulate broad categories that characterize the solution to a type of problem. The broad categories, for example, design logic, are not directly computable from the representation of a solution and, therefore, need to be fleshed out into more basic characterizations that are, in fact, computable. The process is arduous and it involves, in addition to the relevant professional, computer scientists and test developers. The inventors have found that a hierarchical tree representation is both a natural and convenient form of knowledge elicitation.

Scoring Tree Nodes, Clusters, Features and Classifications.

There are basically two types of nodes in the scoring tree hierarchy. One type consists of low-level features requiring a direct computation from the solution, such as computing the location of an element, the distance between design elements, or counting the presence or absence or some elements. The outcome of each feature is a classification into one of four categories: Acceptable (A), Indeterminate (I), Unacceptable (U) and Fatal (F). Initially the thresholds for the categories are set judgmentally, based on the collective expertise of the professionals, for example, architects involved in the project. As data is collected, however, the thresholds are revisited and adjusted as necessary. The system and method of the present invention may also use the following category: Special Processing Required (Q), which is a sort of quality control feature indicating that human oversight may initially be necessary when scoring a particular feature.

The second type of node consists of clusters of lower-level features. Again, the lower level clusters are subsumed under a given higher cluster which is already completed. Indeed, the computation of a vignette score proceeds from the computation of the lower-level features upward in the order dictated by the tree.

Scoring Matrices.

All possible values for a cluster can be represented by a two-dimensional matrix where the rows refer to the number of I's and the columns refer to the number of U's.

The matrix approach to summarize scores is a convenient format to rank the feature cluster measures, and locate tuples to identify the combinations associated with an A, I or U score. The initial process is modified or revisited each time there are changes in problem specifications or other information. Data collected from field trials can be used to suggest further changes. For example, some features may be found not to function well, or be ambiguously defined, or computationally infeasible as originally conceived. Any potential changes are considered very cautiously because all the other instances of the vignette type must be considered in order to avoid the introduction of instance-specific scoring considerations. Occasionally, from such considerations emerges a need to revise the specifications. For example, the initial specifications for the vignette type concerned with lighting and ventilation allowed for the possibility of one or two air supplies and returns. After data was collected on this vignette type, this flexibility was found to be problematic and eliminated.

Scoring Method Particulars for Architects Examination

In a typical vignette exercise, the salient features of a candidate's solution are extracted and promulgated through a hierarchical or "tree-like" scoring structure from which a score for the solution is generated. For example, see FIG. **11**, which is the scoring feature tree for the Accessibility Toilet Vignette. This tree structure is composed of several critical primitive features, each of which feeds into a higher order feature—called a cluster or sub-cluster—which in turn feeds into either a higher order cluster or the vignette's title cluster." See, NCARB, 1994, p. 1, the entirety of which is hereby incorporated herein.

For example, as disclosed in FIG. **11**, "Width" (Feature **1** (see FIGS. **12** and **13**), weight **2**, possible scores of (A), (I) or (U)), "Latch Clearance" (Feature **2** (see FIG. **14**), weight (or multiplier) **1**, possible scores of (A), (I) or (U)) and "Virtual Clearance" (Feature **3** (see FIG. **36**), weight **1**, possible scores of (A), (I) or (U)) are the critical primitive features, which feed into the higher order cluster "Entry Door" (Matrix **2** (see FIG. **36**), weight **1**), which in turn feeds into the vignette's title cluster the "Accessibility Toilet" (Matrix **1** (see FIG. **35**). Some primitive features have possible scores of only (A) or (F). See "Room Configuration" Feature **21**, FIGS. **11** and **34**. While some primitive features have possible scores of only (A) or (U). See FIG. **11** regarding F13. However, note that in another embodiment, this feature has possible scores of (A), (I) and (U). See FIG. **26**.

Extraction.

Scoring works by first reading feature requirements from an authoring file (see "SAMPLE AUTHORING FILE FOR ACCESSIBILITY-TOILET VIGNETTE" in the Source Code Appendix) and comparing the requirements against the data in a candidate's solution file. Second, running the feature checking subroutines and arriving at a score this is called "extraction". The scoring program generates a score of Acceptable (A), Unacceptable (U), Indeterminate (I) or Fatal (F) for each feature that it extracts. See FIGS. **11–34**. See also FIGS. **57–61** for another embodiment of the present invention. The scoring program in another preferred embodiment may also generate a score of Special Processing Required (Q).

Matrix calculation.

Each individual feature that is scored belongs to a matrix, which is a collection of related features. See, for example, FIG. **62**. For another example, the "wind", "solar" and "trees" features all might belong to the "environmental" matrix. Each feature in a matrix is assigned a weight in an authoring file which tells the scoring program how much that particular feature contributes to the score for that matrix. Each matrix has a ctut score associated with it that tells how

many scores of an appropriately weighted (I) or (U) the underlying features of a matrix can have before the matrix score itself no longer qualifies as an (A) and must be scored as an (I) or (U). In one preferred embodiment, there are two cut scores, one between A and I and the other between I and U. The feature scores are weighted as described above before they are tallied. While a matrix is generally made up of features, it may also consist of other "sub"-matrices, each of which have their own features. See, for example, FIGS. 35–41. When all the features have been extracted and the matrix scores have been calculated they are aggregated into one overall score. This overall aggregation involves applying cuts and weights to each of the underlying matrix scores that have been calculated.

Authoring files (".aut").

Authoring files (".aut") contain information need for both delivery and scoring.

Certain authoring files contain feature criteria. These files answer questions such as: (i) if shading is required, how much shading is enough?; (ii) if two building elements must be "close" to each other, how far is too far for a score of "acceptable"?; or (iii) if there is a tolerance for imprecise drafting, how large is that tolerance? For an example of a delivery authoring file see, "SAMPLE AUTHORING FILE FOR ACCESSIBILITY-TOILET VIGNETTE" in the Source Code Appendix.

Scoring matrix files (".mtx").

Scoring matrix files contain matrix information. These files contain matrix information such as: (i) how much is a particular feature weighted, vis-a-vis other features in the matrix; or (ii) how many feature scores of (I) or (U) are necessary for the matrix to get an (I). See, for example, the B3S.MTX file in the Source Code Appendix which relates to the Site Grading Vignette.

Scoring Techniques.

In order to score solutions for certain vignettes, certain techniques had to be developed in order to represent the features of current and potential vignettes and the solution provided by the candidate in a fashion amenable for computer manipulation. Several computer methods were developed by one or more of the co-inventors of the present invention and they are described below.

A Computer Method For Determining If an Object Can Be Viewed From Another Object.

It is necessary in designing public structures to consider what can or cannot be seen from a specified building or other object, called the Source Object. In particular, an architect must consider the question of whether the Target Object is visible or obscured, depending on the desirability of seeing the Target Object. For example, an unobstructed view of a park may be desirable, whereas it may be preferable not to see a parking lot.

A two-dimensional computer method is disclosed in the program set forth at section VIEW SOURCE CODE of the Source Code Appendix for determining the percentage of the Target Object that is visible from one side of the Source Object.

For additional information the reader is directed to Reid-Green (1996d), which is hereby incorporated herein.

A Computer Method for Calculating Setback Polygons.

In architecture, a setback is an area, generally described by a fixed distance from a site feature--a building, road, lot line, etc.—inside which no structure may be built. A setback can be defined as the locus of all points which are a fixed distance outside or inside an arbitrary polygon.

For example, consider a site plan with existing structures such as buildings, driveways, etc., and the definition of various setbacks, for example, a setback of five feet from the edge of the site. Therefore any structure to be built on the site must be at least five feet away from all site boundaries. A computer implemented method to determine success in conforming to setback requirements must determine if any lines defining the new structure intersect any setbacks. To be consistent with the practice of approximating an arc by a series of connected line segments, it is necessary to provide a means to generate a polygonal approximation to a given polygon which is the setback to the given polygon.

The program set forth at section SETBACKS SOURCE CODE of the Source Code Appendix discloses one embodiment of this method.

For additional information the reader is directed to Reid-Green (1996c), which is hereby incorporated herein.

A Computer Method for Determining Building Insolation and Shadow.

The purpose of this method and its underlying algorithm is to verify that a new building is located so that it will not cast shadows on existing buildings during business hours. This and other questions dealing with sunlight and shadows can be determined from the apparent motion of the Sun on the solstices, approximately June 22nd and December 22nd. For additional information the reader is directed to Reid-Green (1996a), which is hereby incorporated herein.

A Computer Method for Verification of Wheelchair Accessibility in an Office.

The purpose of this method and its underlying algorithm is to verify that the design of an office is such that a wheelchair user can move around in it. Specifically, it must be possible for the wheelchair to have a free path to the telephone, computer terminal, etc., and it must be possible to turn the wheelchair around. For additional information as to one embodiment of such a computer method, the reader is directed to Reid-Green (1996b), which is hereby incorporated herein.

DETAILED DESCRIPTION OF ONE PREFERRED EMBODIMENT: THE ACCESSIBILITY—TOILET ROOM VIGNETTE

Description of a Vignette

The Accessibility—Toilet Room Vignette is set as a design development problem that assesses a candidate's ability to plan one or more accessible toilet rooms within the context of a given area. The exercise tests the candidate's ability to apply design logic and meet the requirements of a simple program, as well as to interpret accessibility code requirements in the development of space plans.

The candidate is given the floor plan of an undeveloped area along with adjacent corridor(s) in the building where one to three toilet rooms are to be located. The footprint of this area is of a predetermined size and configuration. The provided program includes fixture requirements as well as a clear indication of expected functional performance with respect to view screening. The menu of physical objects to be selected, manipulated, and placed using icons provided includes plumbing fixtures, accessories, wall elements with which to construct the plan, and door-swing symbols.

The candidate must design the space or spaces as required and place all walls, fixtures, accessories, and doors necessary to complete the floor plan.

Scoring of Vignette

The candidate's solution is analyzed for completeness, accuracy, and compliance with code and program requirements.

Required Materials for Vignette

a) Scenario for the vignette.

b) Statement of program objectives including functional, fixture, and screening requirements along with all other pertinent background information.

c) Code requirements and restrictions as applicable.

d) Floor plan of pre-configured area to be developed showing its relationship to the adjacent corridor(s). Outside walls of corridors should be indicated by double solid lines.

e) Graphic tools for drawing walls, fixtures, accessories, and doors.

Authoring Requirements of Vignette

a) The program space to be developed should be between 320 and 430 square feet [30–40 m^2], reasonably confined, but sufficient to allow for multiple correct solutions (square footprints permit the greatest variety). This space should be indicated by double dashed lines on the floor plan.

b) One to two sides of the program area must be adjacent to a corridor along their full length.

c) Program area should be adequate for inclusion of fixtures and accessories required by program and code.

d) Required fixtures and accessories must include a total of 1–2 accessible showers or an infant changing tables.

e) 9 to 12 plumbing fixtures should be required.

f) One to three toilet rooms should be required, and at least one of the toilet rooms should be an accessible toilet room.

g) View screening should be required.

h) All measurements should be in multiples of 2 inches [50 mm] and the plan should be on a 2 inch [50 mm] grid.

Technical Overview

Authoring: See sample authoring file entitled "SAMPLE AUTHORING FILE FOR ACCESSIBILITY-TOILET VIGNETTE" in the Source Code Appendix, which contains delivery information, but no scoring information.

Smart Delivery: All room labels should be used before the candidate is permitted to leave the vignette.

Interface: Draw The candidate must both draw and place elements in this vignette.

Elements Which Are to Be Drawn or Placed.

4" Wall (called 100 mm wall in metric vignettes)

8" Wall (called 200 mm wall in metric vignettes)

Doors

Grab Bar

Lavatory

Handicapped Lavatory

Room Labels

Shower (or bidet, depending on script)

Stall

Urinal

Handicapped Urinal

Water Closet

Handicapped Water Closet

Breakdown of Each Element.

4" Wall

The 4" wall is drawn in the way described in FIG. 42.

8" Wall

Same as for 4" Wall above and in FIG. 42, only wider.

Doors

All possible orientations and swings should be available. A secondary pop up should allow selection of widths from 20 to 48 inches, in 4 inch increments. Allow an unlimited number to be drawn.

Grab Bar

Grab bars should be .dwg objects, 3'6" in length, with wall connectors. The rotate icon will rotate grab bars 90 degrees at a time to the desired orientation. Allow an unlimited number to be drawn.

Lavatory and Handicapped Lavatory

Both are .dwg objects. The rotate icon will rotate the lavatory 90 degrees at a time to the desired orientation. Allow an unlimited number to be drawn.

Room Labels

This option will allow the candidate to place a literal from a pop up menu to each created toilet room. If possible, the actual literal should be visible when animated into position. Allow only one of each to be placed.

Shower

Shower is a .dwg object. The rotate icon will rotate the shower 90 degrees at a time to the desired orientation. Allow an unlimited number to be drawn.

Bidet

Bidet is a .dwg object. The rotate icon will rotate the bidet 90 degrees at a time to the desired orientation. Allow an unlimited number to be drawn.

Stall

Stall is a rubberbanding double walled box with 1" between the walls at all magnifications. When doors are placed on a stall, they should cause a break in the wall. When the wall of a stall overlaps an existing or drawn wall, the stall wall should disappear. Allow an unlimited number to be drawn.

Urinal and Handicapped Urinal

Both are .dwg objects. The rotate icon will rotate the urinal 90 degrees at a time to the desired orientation. Allow an unlimited number to be drawn.

Water Closet and Handicapped Water Closet

Both are .dwg objects. The rotate icon will rotate the water closet 90 degrees at a time to the desired orientation. Allow an unlimited number to be drawn.

Move/Adjust

The move icon will allow the candidate to move any .dwg objects, or move or adjust any drawn objects (like stalls, walls).

As stalls are drawn orthogonal boxes, the candidate should be able to grab any wall and drag.

Walls have a fixed width, so only the length should be adjustable.

Move Group

To work as usual: objects are selected individually, moved as a group.

Rotate

To rotate .dwg objects 90 degrees.

Icons

The standard set of icons common to all vignettes should appear as well, see FIGS. **2–10, 43–49, 52–53, 63–66.**

Grid Snap 2 inches.

ACCESSIBILITY—TOILET ROOM FEATURES

Certain of the Accessibility—Toilet Room Vignette problem features were discussed in the earlier section entitled

Solution Scoring System. A detailed discussion of the features for one preferred embodiment of the present invention follows below.

FIGS. **35–41** show the Master Features Matrix and feature cluster matrices for one preferred embodiment of the Accessibility-Toilet Room Vignette.

ANOTHER PREFERRED EMBODIMENT THE HYPOTHETICAL BATHROOM REMODEL VIGNETTE

Scenario.

The candidate is instructed to re-design a master bathroom starting with a pregutted floor plan; using the drawing tools provided and using all the fixtures, cabinets and lighting given in the program. See FIG. **68**.

Program.

On the given floor plan the candidate is instructed to place the following cabinets, fixtures and accessories:

1. 60"×30" Bathtub;
2. Toilet;
3. 30" wide×18" deep freestanding linen cabinet;
4. 42" inch wide×18" deep Vanity Cabinet;
5. Sink;
6. 3 recessed incandescent ceiling Lighting Fixtures; and
7. Fuzzy Rug and Toilet Seat Cover.

Scoring.

The scoring tree or feature evaluation map used to evaluate the solutions is shown in FIG. **67**. The first branch or cluster from the left (**M2**) comprises features relating to the plumbing fixtures to be located in the remodeled bathroom. The second and third clusters (**M3** and **M4**) comprise features relating to the placement of accessories and cabinets, respectfully. Those features relating to the location of lights are evaluated in the fourth cluster (**M5**). The fifth cluster (**M6**) comprises features relating to the completeness of the solution. Located below the Fixtures cluster (**M2**) are three subclusters labeled Toilet (**M7**), Lavatory (**M8**) and Bathtub (**M9**). Below each of these three subclusters are several features which must be scored first in order to subsequently determine a score for the subcluster.

As noted earlier, scoring procedure employs a system of three ordered categories. These categories correspond to the insertion of an intermediate, or indeterminate, category (I) between the clearly acceptable (A) and the clearly unacceptable (U). Hence, a designation of "A" indicates the demonstration of an acceptable level of ability; "I" indicates a level of ability that is neither clearly acceptable nor clearly unacceptable; and "U" indicates an unacceptable level of ability.

The first feature (**F1**) below the Toilet subcluster (**M7**) evaluates whether or not the back of the toilet is located adjacent to a plumbing wall. In so doing, the scoring system searches the solution for a toilet. If one is found, the system determines whether or not its back is within an acceptable distance from a plumbing wall (with a stack vent indicated). If the back is either between 3" and 6" away or up to 1" into the wall, an "I" is assigned.

The feature is assigned a "U" if the condition is other than those formerly described. In a first hypothetical solution (FIG. **69**), the back of the toilet is placed on the face of the wall in which an existing vent stack is indicated. Thus, the scoring system assigns an "A" to this feature.

In a second hypothetical solution (FIG. **70**), the back of the toilet is located adjacent to a wall with no vent stack indicated. As a result, a "U" is assigned to the feature in this case. It is important to note that the thresholds and tolerances for each feature in a vignette's scoring tree are derived and refined iteratively through expert judgment (i.e. the judgment of architect practitioners and educators with considerable knowledge and experience in examination scoring procedures).

Factors such as screen resolution and grid snap values, as well as possible variations in expert opinion, are typical considerations in determining these values.

The second feature (**F2**) below cluster **M7** checks the distance between the centerline of the toilet and a wall or any obstruction to either side. If the nearest face of a wall, fixture or cabinet is a perpendicular distance of 15" or more from the centerline of the toilet, an "A" is assigned to this feature. If the nearest face is between 14" and 15" from the centerline, an "I" is assigned. Any condition closer than 14" is assigned a "U".

If we assume that FIG. **69** shows a toilet located so that its centerline is 18" from both the nearest wall on one side and the end of the vanity on the other. This feature, therefore, satisfies the condition for an "A". Likewise. Assume, that Solution B also satisfies the condition for an "A".

The third feature (**F3**) below cluster **M7** checks for the required clearance on front of the toilet. This feature might be used to illustrate the occasional instance where an indeterminate category is considered inappropriate or unnecessary by experts. In this case, an "A" is assigned if the nearest face of a wall, fixture or cabinet is a perpendicular distance of 29" or more in front of the toilet. Any condition closer than 29" is assigned a "U". In this case, therefore, there are only two possible scores which can be assigned "A" or "U", that is, there is no "I" score. Again, assume Solution A is assigned an "A", and Solution B is assigned a "U" for this condition.

The three features scored above are the primitives of subcluster **M7**. All of the primitives below each subcluster or cluster are evaluated in a similar fashion, each having its own set of scoring rules to determine the appropriate thresholds and tolerances. The result is an assignment of a score category (A, I or U) for each individual primitive.

The next step in the scoring process is to combine the scores assigned to the primitives with each other to generate a score category for their respective subcluster or cluster. In order to do this, a weighting value must be assigned to each of the previously scored features for the purpose of defining the importance of each feature in relation to the others within the same cluster or subcluster. In the example discussed above, the features comprising subcluster **M7** (**F1**, **F2** and **F3**), must be weighted in relation to each other before they can be combined to produce a score for subcluster **M7**.

According to the scoring tree (FIG. **67**), the experts have determined that feature **F3** (Front Clearance) is more important that features **F1** and **F2**. As a result, feature **F3** is double counted, or given a weighting value of two (2), against a value of one (1) each for features **F1** and **F2**.

The possibility of three (3) score values (A, I or U) each for features **F1** and **F2** and two (2) score values (A or U) for feature **F3** results in a range of 18 possible combinations, each of which results in a score category for subcluster **M7**. Each combination can be summarized by the counts of any two of the three possible values. Therefore, all possible combinations of "U"s and "I"s are plotted on a two dimensional matrix, where the rows refer to the number of "I"s and the columns refer to the number of "U"s. See FIG. **67** (**M7**). Each cell in this matrix is associated with a score for subcluster **M7**. Since FIG. **69** A was assigned an "A" for all three features (**F1**, **F2** and **F3**), it is assigned a "A" in subcluster **M7** (zero "I"s, zero "U"s). FIG. **70** was assigned

a "U" for feature F1, an "A" for feature F2 and a "U" for feature F3, resulting in a count of three (3) "U"s, zero "I"s and one "A". According to FIG. 67 (M7), this results in a score of "U" for subcluster M7 in the case of Solution B.

Subclusters M8 and M9 must be processed, along with the features that feed into them, in a manner similar to M7, after which, the scores assigned to the three subclusters (M7, M8 and M9) are combined in a matrix to produce a score for cluster M2. A process identical in nature to that described in the preceding discussion is executed at each cluster (M3, M4, M5 and M6) in the scoring tree/evaluation map. Finally the six scored clusters are combined, with appropriate weighting values, in the vignette's master matrix to produce a score (A, I or U) for the vignette.

Fixtures Cluster (M7, M8 and M9).

Both types of nodes, features and clusters scores, can take on three values: A, I, or U. In the case of the Fixtures cluster (see FIG. 67), which is composed of three lower-level features (Toilet, Lavatory and Bathtub), there are 27 (3×3×3) different possible "input" feature values; these are partially enumerated in Table 1 below. Each such outcome can be summarized by the counts of any two of the three possible values. The U's and I's have been used as the summary of an outcome measure as seen in the last two columns of Table 1. All possible values for a cluster can be represented by a two-dimensional matrix where the rows refer to the number of I's and the columns refer to the number of U's.

TABLE 1

Enumeration of Feature Values Corresponding to Toilet, Lavatory and Bathtub Clusters

Feature Value Sets	Fixture Cluster			Counts	
	Toilet	Lavatory	Bathtub	U	I
1.	A	A	A	0	0
2.	I	A	A	0	1
3.	A	I	A	0	1
4.	A	A	I	0	1
5.	I	I	A	0	2
6.	I	A	I	0	2
7.	A	I	I	0	2
8.	I	I	I	0	3
9.	U	A	A	1	0
10.	A	U	A	1	0
11.	I	U	I	2	2
12.	U	I	I	1	2
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
27.	U	U	U	3	0

Table 2, below, is a possible matrix for the Fixture cluster. According to this matrix, an "A" corresponds to feature value set #1 with zero I's and Zero U's (e.g. the feature value set #1 in Table 1). An "I" corresponds to feature value set number with one I and zero U's (e.g., feature sets #2, #3, and #4 in Table 1.) All other feature value sets get assigned a U.

TABLE 2

Summary Matrix for Fixture Cluster

I's \ U's	0	1	2
0	A	U	U
1	I	U	U
2	U	U	U
3	U	U	U

Although preferred embodiments of the present invention have been described above in detail, it is desired to emphasize that this has been for the purpose of illustrating and describing the invention, and should not be considered as necessarily limiting the invention, it being understood that many modifications can be made by those skilled in the art while still practicing the invention claim herein.

SOFTWARE FILE STRUCTURE

.m13 files.

Contain the reference information for the particular vignette. The files comprise the text and graphics for those portion of the index screen (see, for example, FIG. INDEX SCREEN), which include the following task information topics: "Vignette Directions"; "Program"; "Tips"; and "Review of the General Test Directions". These files are referenced by the corresponding .aut file.

Several vignette specific references are included in one preferred embodiment of the present invention as well. These include lighting diagrams, building elevations, building sections and tree diagrams.

.aut files.

Reference the files required by the corresponding delivery and scoring programs, and contain all non-graphical information required by delivery and scoring. For example, they contain specific feature values and criterion used by scoring.

.dwg files.

AutoCAD objects such as the following, which appear in one preferred embodiment of the present invention, namely: the lavatory, shower, bidet, water closet, etc. The drawings provide all graphical information required by the delivery and scoring programs.

.mtx files.

Matrix files provide tuples and weights required to allow scoring programs to translate feature scores into an overall score for the vignette. They contain information on the weights of features and which features feed into which matrixes and which squares of matrix are possible and what the cut-offs are.

.dll files.

Dynamic link libraries provide by third party software vendors (Borland, AutoCAD) and written internally that contain core functionality required by all delivery and scoring programs.

.log files.

Contain the candidates' "scores". They also contain verbose information about conditions encountered while scoring a particular solution that allow for validation that the scoring program is working correctly.

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We claim:

1. A computerized system for the professional assessment of architects, civil engineers, aeronautical engineers, mechanical engineers, naval engineers, interior designers, landscape designers, and architectural designers, by the creation, presentation to a test candidate, and scoring of a test item in the form of a computer-based simulation of professional practice, wherein the system comprises:

an authoring subsystem for creating a computer-based simulation of professional practice test item;

a delivery subsystem which assembles the test item for the test candidate, presents the test item to the test candidate, provides computerized tools to the test candidate for use in solving the test item, and stores the solution; and

a scoring subsystem which decomposes, analyzes and scores the solution.

2. The computerized system of claim **1** wherein the authoring subsystem comprises means for creating and establishing scoring rules and criteria for test items.

3. The computerized system of claim **2** wherein the authoring subsystem further comprises means for specifying the names and attributes of spaces that will comprise a unique script.

4. The computerized system of claim **1** wherein the delivery subsystem comprises means for assembling a complete test item for a test candidate based on instructions stored in an authoring file.

5. The computerized system of claim **4** wherein said instructions direct the delivery subsystem:

to reference various files stored in multiple formats and locations; and

how to present certain features, options, menus, and drawing elements to a test candidate.

6. The computerized system of claim **1** wherein the authoring subsystem comprises FRAMEWORK software which has been compiled as a dynamic link library.

7. The computerized system of claim **6** wherein the dynamic link library includes a library of computer code representing geometric objects.

8. The computerized system of claim **6** wherein the dynamic link library is comprised of the following kinds of files: COMPONENT files; CONTROL files; DWG files; EVENTS files; FEATURES files; GEOMETRY files; GRAPHICS files; HDR files; MOUSETRK files; OBJS files; OSA files; OSACALC files; PERSTGEO files; APPLICAT files; SCORING files; TRANSACT files; VGNOBJEC files; VGNTASKS files; VGNWIND files; and WINDOWS files.

9. The computerized system of claim **1** wherein the delivery subsystem of the present invention interfaces with a test administration system.

10. The computerized system of claim **9** wherein the test administration system is Open System Architecture (OSA).

11. The computerized system of claim **1** wherein the scoring subsystem comprises:

means for decomposing a test candidate's solution; and

means for analyzing said solution.

12. The computerized system of claim **1** wherein the assessment comprises vignette test items directed to building design problems.

13. The computerized system of claim **12** wherein the test item comprises a site section vignette.

14. The computerized system of claim **13** further comprising an index screen.

15. The computerized system of claim **13** further comprising an vignette directions screen.

16. The computerized system of claim **13** further comprising an program screen.

17. The computerized system of claim **13** further comprising a tips screen.

18. The computerized system of claim **13** further comprising a general test directions screen.

19. The computerized system of claim **12** wherein the test item comprises a site analysis vignette.

20. The computerized system of claim **12** wherein the test item comprises a site grading vignette.

21. The computerized system of claim **20** further comprising a vignette directions screen.

22. The computerized system of claim **20** further comprising a program directions screen.

23. The computerized system of claim **20** further comprising a tips screen.

24. The computerized system of claim **20** further comprising a scoring decision tree.

25. The computerized system of claim **20** further comprising features scoring.

26. The computerized system of claim **25** further comprising a scoring decision tree.

27. The computerized system of claim **25** further comprising features scoring.

28. The computerized system of claim **25** further comprising a master features matrix.

29. The computerized system of claim **20** further comprising a features matrix.

30. The computerized system of claim **20** further comprising site grading vignette solution source code.

31. The computerized system of claim **12** wherein the test item comprises a zoning section vignette.

32. The computerized system of claim **31** further comprising the feature matrices.

33. The computerized system of claim **12** wherein the test item comprises a site parking vignette.

34. The computerized system of claim **12** wherein the test item comprises a site design vignette.

35. The computerized system of claim **1** wherein the assessment comprises vignette test items directed to site design problems.

36. The computerized system of claim **35** wherein the test item comprises a schematic design vignette.

37. The computerized system of claim **35** wherein the test item comprises a schematic structural design vignette.

38. The computerized system of claim **35** wherein the test item comprises a mechanical and electrical plan vignette.

39. The computerized system of claim **35** wherein the test item comprises a building section vignette.

40. The computerized system of claim 35 wherein the test item comprises a accessibility—ramp vignette.

41. The computerized system of claim 35 wherein the test item comprises a accessibility—toilet room vignette.

42. The computerized system of claim 41 further comprising Sample Authoring File for Accessibility-Toilet Vignette source code.

43. The computerized system of claim 35 wherein the test item comprises a stair design vignette.

44. The computerized system of claim 35 wherein the test item comprises a roof plan vignette.

45. The computerized system of claim 35 wherein the test item comprises an interior layout vignette.

46. A computerized method for the assessment of architects by the creation, presentation to a test taker, and scoring of a test item in the form of a computer-based simulation of architectural practice, comprising the steps of:

authoring a test item in the form of a computer-based simulation of architectural practice using a dynamic link library comprising geometric objects;

delivering the test item to a test taker and providing the test taker with the tools necessary to provide a response to the test item; and

scoring the test taker's response by using a hierarchical organization of problem features needed to characterize performance and decomposing the test taker's response.

47. The computerized method of claim 46 wherein the tools provided to the test taker are comprised of common and unique tools.

48. The computerized method of claim 47 wherein the common tools further comprise: SKETCH icon tools; ORTHO icon tool; ZOOM icon tool; CURSOR icon tool; UNDO icon tool; ERASE icon tool; ID icon tool; CALC icon tool; TASK INFO icon tool; START OVER icon tool; and a REVIEW icon tool.

49. The computerized method of claim 47 wherein the unique tools further comprise: CHECK OVERLAPS icon tools; DRAW icon tool; MOVE ADJUST icon tool; MOVE GROUP icon tool; ROTATE icon tool; LAYERS icon tool; OPTIONS icon tool; and a SET ROOF icon tool.

50. The computerized method of claim 47 wherein the step of scoring the test taker's response comprises:

feature extraction; and

matrix calculation.

51. The computerized method of claim 50 wherein feature extraction comprises:

reading feature requirements from an authoring file;

comparing the requirements against data in a test taker's solution file; and

determining a score of Acceptable (A), Indetermined (I) or Unaccceptable (U) for each feature.

52. The computerized method of claim 50 wherein feature extraction comprises:

reading feature requirements from an authoring file;

comparing the requirements against data in a test taker's solution file; and

determining a score of Acceptable (A), Indeterminate (I), Unacceptable (U) or Fatal (F) for each feature.

53. The computerized method of claim 50 wherein matrix calculation comprises:

assigning each feature to a sub-matrix;

assigning a weight to each feature in a sub-matrix;

scoring the sub-matrix as either Acceptable (A), Indeterminate (I) or Unacceptable (U); by associating a cut score with the matrix which determines how many scores of an appropriately weighted feature scores of either (I) or (U) the matrix can have before the matrix is to be scored as an (I) or (U);

assigning, as applicable, each sub-matrix and its score to a sub-matrix or second sub-matrix which second matrix comprises feature scores and other sub-matrix scores;

assigning a weight to each feature and sub-matrix in a matrix;

scoring the matrix as either (A), (I) or (U) by associating a cut score with the matrix which determines how many scores of an appropriately weighted feature scores or sub-matrix scores of either (I) or (U) the matrix can have before the matrix is to be scored as an (I) or (U); and

continuing the above steps until all features and sub-matrices have been scored and a final overall score determined.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,056,556
DATED : May 2, 2000
INVENTOR(S) : Henry I. Braun et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title page,
Insert after "53 Claims, 70 Drawing Sheets" the following.
-- (4 Microfiche, 342 Frames) --

Column 4,
Line 13, before the BACKGROUND OF THE INVENTION, please add the following,
-- MICHROFICHE APPENDIX

This patent document includes a computer program listing in the form of a Microfiche Appendix consisting of 4 microfiche with a total of 342 frames. --

Please cancel all references to "Source Code Appendix" and in its place substitute -- Microfiche Appendix --.

Column 2,
Line 65, cancel "Source Code Appendix" and in its place insert -- Microfiche Appendix --.

Column 10,
Lines 38-39, cancel "Source Code Appendix" and in its place insert -- Microfiche Appendix --.

Column 20,
Lines 48-49, cancel "Source Code Appendix" and in its place insert -- Microfiche Appendix --.

Column 21,
Line 26, cancel "Source Code Appendix" and in its place insert -- Microfiche Appendix --.

Column 21,
Line 33, cancel "Source Code Appendix" and in its place insert -- Microfiche Appendix --.
Line 55, cancel "Source Code Appendix" and in its place insert -- Microfiche Appendix --.

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,056,556
DATED : May 2, 2000
INVENTOR(S) : Henry I. Braun et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 22,
Line 12, cancel "Source Code Appendix" and in its place insert -- Microfiche Appendix --.

Column 23,
Line 47, cancel "Source Code Appendix" and in its place insert -- Microfiche Appendix --.

Signed and Sealed this

Fifth Day of March, 2002

Attest:

Attesting Officer

JAMES E. ROGAN
Director of the United States Patent and Trademark Office

US006532334B1

(12) **United States Patent**
Kikuchi et al.

(10) **Patent No.: US 6,532,334 B1**
(45) **Date of Patent: Mar. 11, 2003**

(54) **INFORMATION REPRODUCING SYSTEM, INFORMATION RECORDING/ REPRODUCING SYSTEM, AND RECORDING MEDIUM APPLICABLE TO THE SYSTEM**

(75) Inventors: **Shinichi Kikuchi**, Yokohama (JP); **Yuji Ito**, Tokyo (JP); **Kazuhiko Taira**, Yokohama (JP)

(73) Assignee: **Kabushiki Kaisha Toshiba**, Kawasaki (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 247 days.

(21) Appl. No.: **09/819,023**

(22) Filed: **Sep. 6, 2000**

Related U.S. Application Data

(63) Continuation of application No. 09/582,227, filed as application No. PCT/JP99/00211 on Jan. 21, 1999, now abandoned.

(30) **Foreign Application Priority Data**

Jan. 21, 1998 (JP) 10-009901

(51) **Int. Cl.**[7] **H04N 5/91**

(52) **U.S. Cl.** **386/68**; 386/70; 386/95; 386/125

(58) **Field of Search** 386/125–126, 386/124, 82, 68, 70, 111, 109, 95; H04N 5/91

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Japanese Office Action (Notification of Reasons for Rejection) re: Japanese Patent Application 2002–146534, Mailing Date: Sep. 10, 2002, Mailing No. 302840 (with English translation).
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* cited by examiner

Primary Examiner—Vincent Boccio
(74) *Attorney, Agent, or Firm*—Oblon, Spivak, McClelland, Maier & Neustadt, P.C.

(57) **ABSTRACT**

In an information recording medium on which video information can be recorded, control information **78** is stored in its data area **76**. Following the control information **78**, a video object **82** to be reproduced is stored. The control information **78** includes playback interrupt information **124** for resuming playback during the interruption of playback. An area for the process is provided. This makes it possible to reproduce the picture next time where the playback was interrupted, referring to the playback interrupt information **124**. Consequently, even when the disk is removed from the video-recordable reproducing system, reinstalling the disk into the system makes it possible to play back the disk where the playback was interrupted.

7 Claims, 18 Drawing Sheets

PLY_MAT

RBP		DESCRIPTION	NUMBER OF BYTES
0 TO 11	ID	IDENTIFIER	12 BYTES
12 TO 15	VOBS_SA	START ADDRESS OF VOBS	4 BYTES
16 TO 19	VOBS_EA	END ADDRESS OF VOBS	4 BYTES
20 TO 23	CTLI_EA	END ADDRESS OF CTLI	4 BYTES
24 TO 24	PLYCI_EA	END ADDRESS OF PLYCI	4 BYTES
25 TO 28	CAT	CATEGORY	4 BYTES
29 TO 30	V_ATR	VIDEO ATTRIBUTE	2 BYTES
31 TO 32	AST_Ns	NUMBER OF AUDIO STREAMS	2 BYTES
33 TO 34	AST_ATRT	AUDIO STREAM ATTRIBUTE TABLE	2 BYTES
35 TO 36	SPST_Ns	NUMBER OF SUB-PICTURE STREAMS	2 BYTES
37 TO 38	SPST_ATRT	SUB-PICTURE ATTRIBUTE TABLE	2 BYTES
39 TO 39	USER MENU EXIST_FLAG	USER MENU PRESENT/ABSENT FLAG 01: FILE PRESENT, 00: FILE ABSENT	1 BYTE
40 TO 40	MAIN PCG NUMBER	PGC NUMBER OF REPRESENTATIVE REDUCED PICTURE	2 BYTES
41 TO 44	RESERVED	RESERVATION	4 BYTES
45 TO 45	PLAY_END FLAG	FLAG FOR PLAYBACK END 0: UNREPRODUCED, 1: REPRODUCED	1 BYTE

RSM_MRK

RBP		DESCRIPTION
134	PGCN	PGC NUMBER
135	PGN	PG NUMBER
136 TO 137	CN	CELL NUMBER
138 TO 143	MRK_PT	MARKER POINTER
144 TO 148	MRK_TM	TIME WHEN MARKING IS DONE

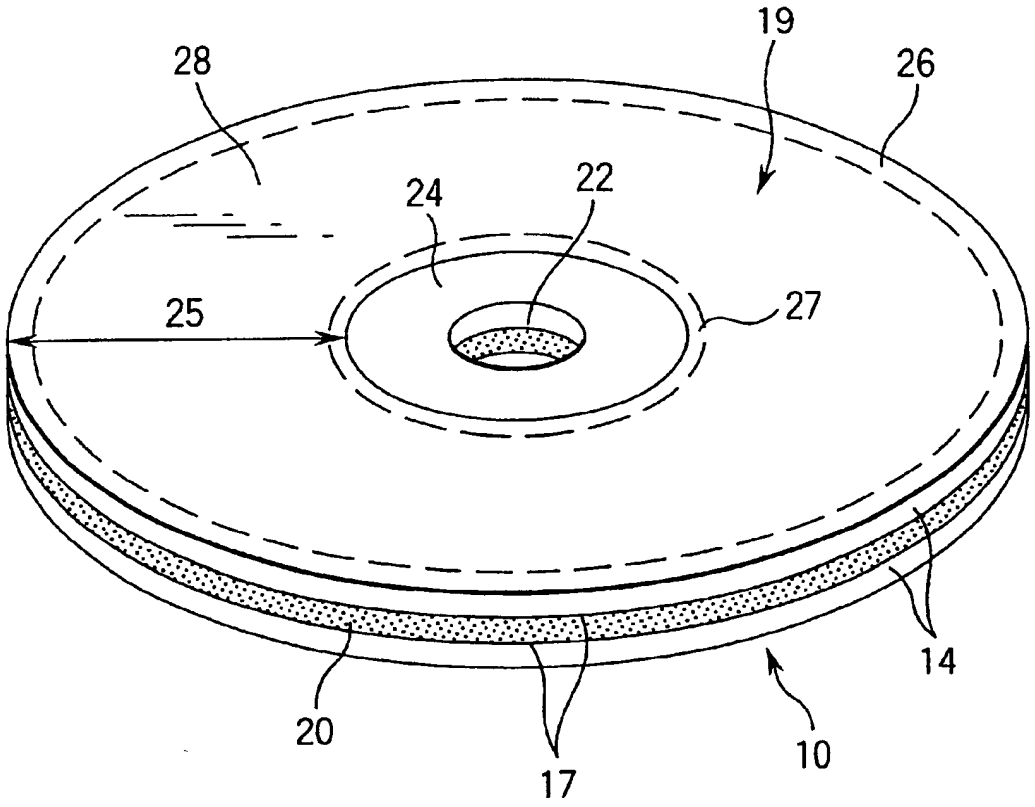

FIG. 1

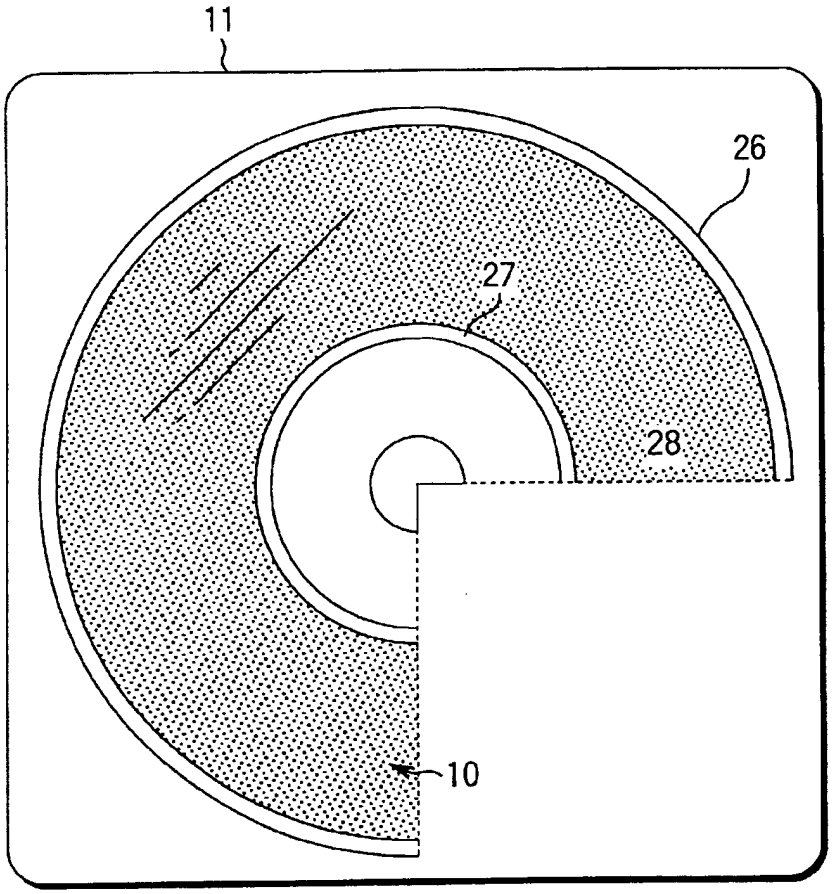
11
26
27
28
10

FIG. 2A

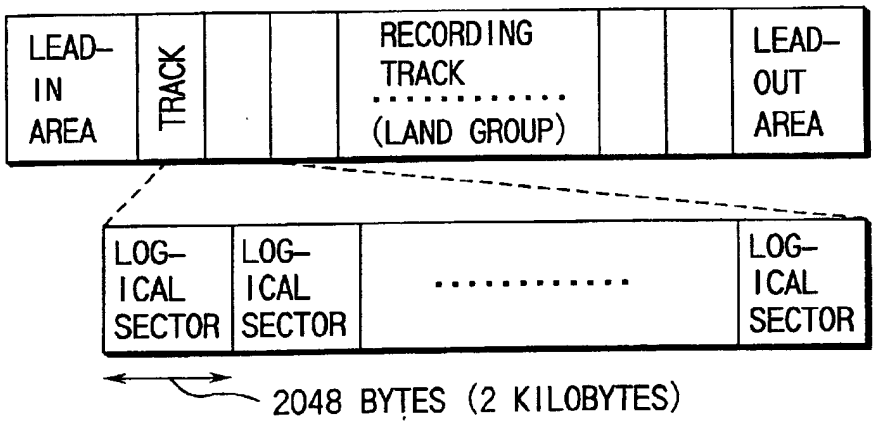
LEAD-IN AREA
TRACK
RECORDING TRACK
(LAND GROUP)
LEAD-OUT AREA
LOG-ICAL SECTOR
LOG-ICAL SECTOR
LOG-ICAL SECTOR
2048 BYTES (2 KILOBYTES)

FIG. 2B

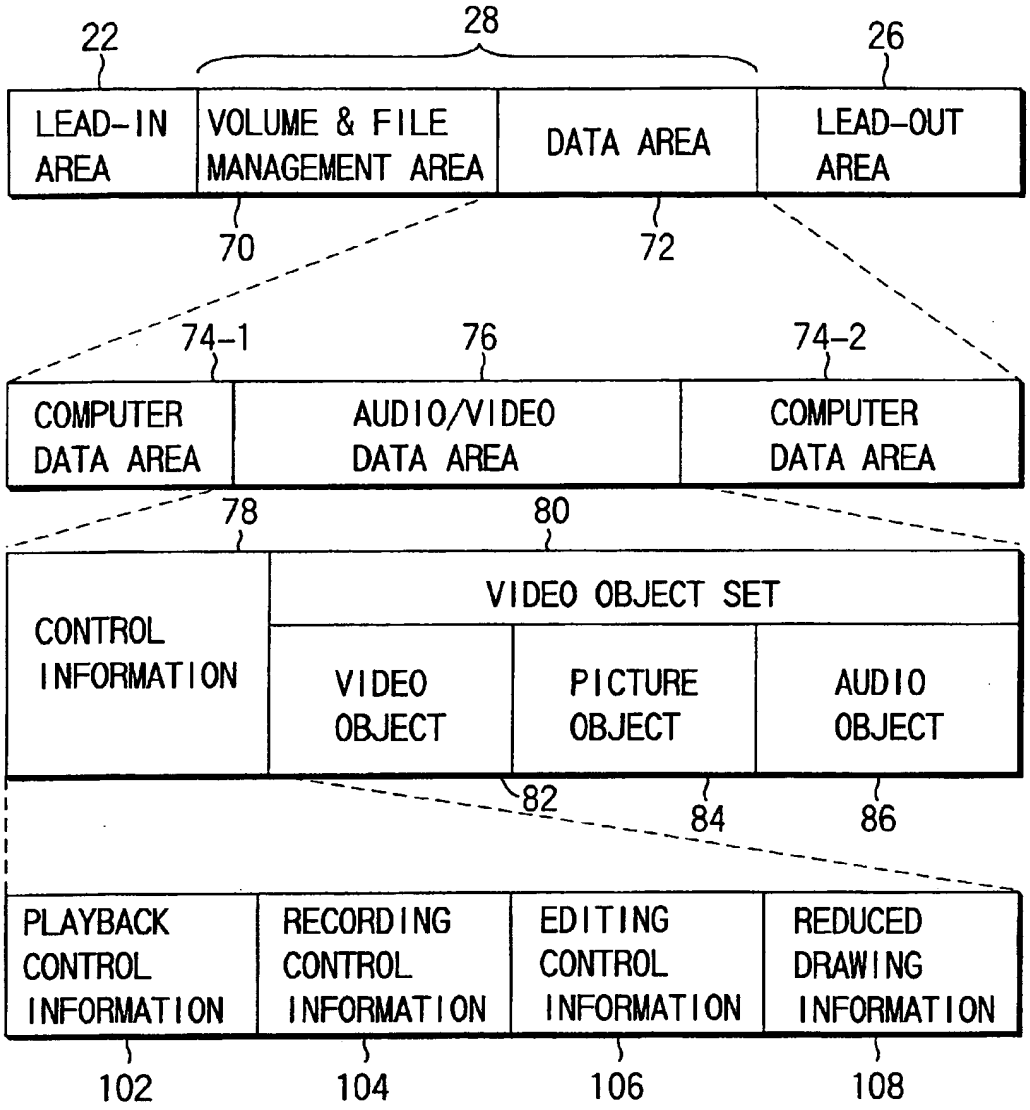
22
28
26
LEAD-IN AREA
VOLUME & FILE MANAGEMENT AREA
DATA AREA
LEAD-OUT AREA
70
72
74-1
76
74-2
COMPUTER DATA AREA
AUDIO/VIDEO DATA AREA
COMPUTER DATA AREA
78
80
CONTROL INFORMATION
VIDEO OBJECT SET
VIDEO OBJECT
PICTURE OBJECT
AUDIO OBJECT
82
84
86
PLAYBACK CONTROL INFORMATION
RECORDING CONTROL INFORMATION
EDITING CONTROL INFORMATION
REDUCED DRAWING INFORMATION
102
104
106
108

FIG. 3

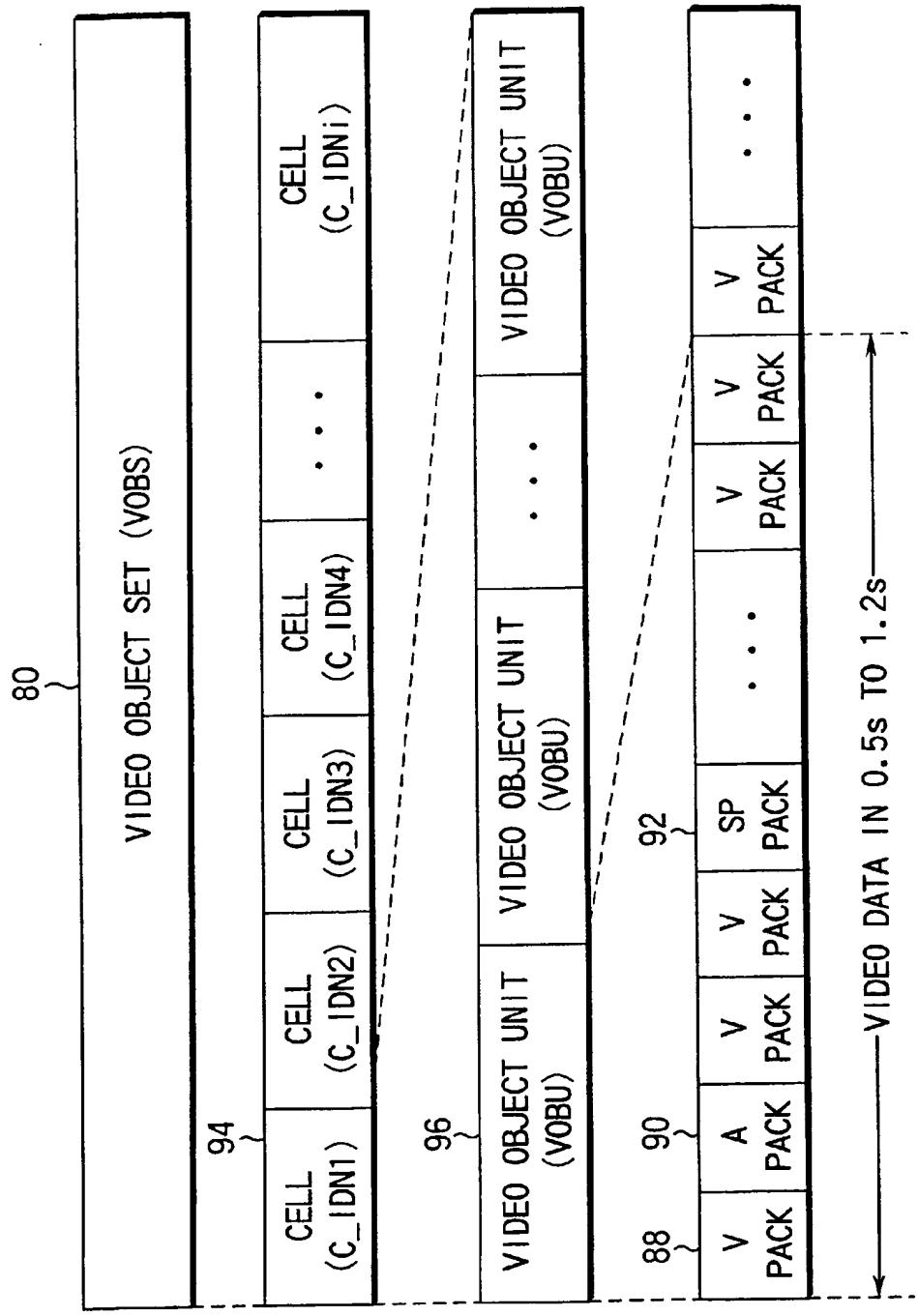
80
VIDEO OBJECT SET (VOBS)
94
CELL (C_IDN1)
CELL (C_IDN2)
CELL (C_IDN3)
CELL (C_IDN4)
. . .
CELL (C_IDNi)
96
VIDEO OBJECT UNIT (VOBU)
VIDEO OBJECT UNIT (VOBU)
. . .
VIDEO OBJECT UNIT (VOBU)
92
88
90
V PACK
A PACK
V PACK
V PACK
SP PACK
. . .
V PACK
V PACK
V PACK
. . .
VIDEO DATA IN 0.5s TO 1.2s

FIG. 4

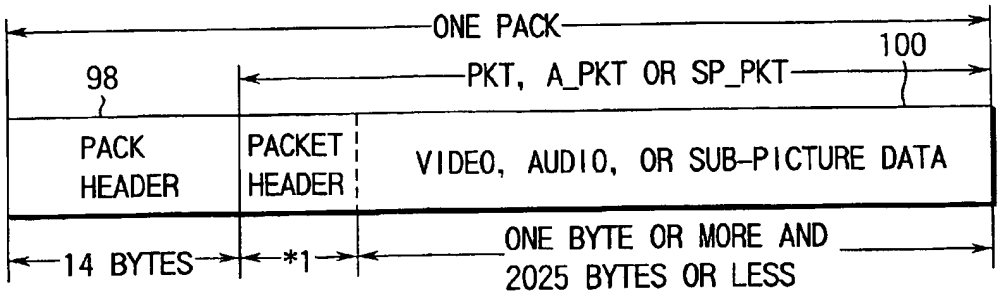
ONE PACK
98
PKT, A_PKT OR SP_PKT
100
PACK HEADER
PACKET HEADER
VIDEO, AUDIO, OR SUB-PICTURE DATA
14 BYTES
*1
ONE BYTE OR MORE AND 2025 BYTES OR LESS

FIG. 5

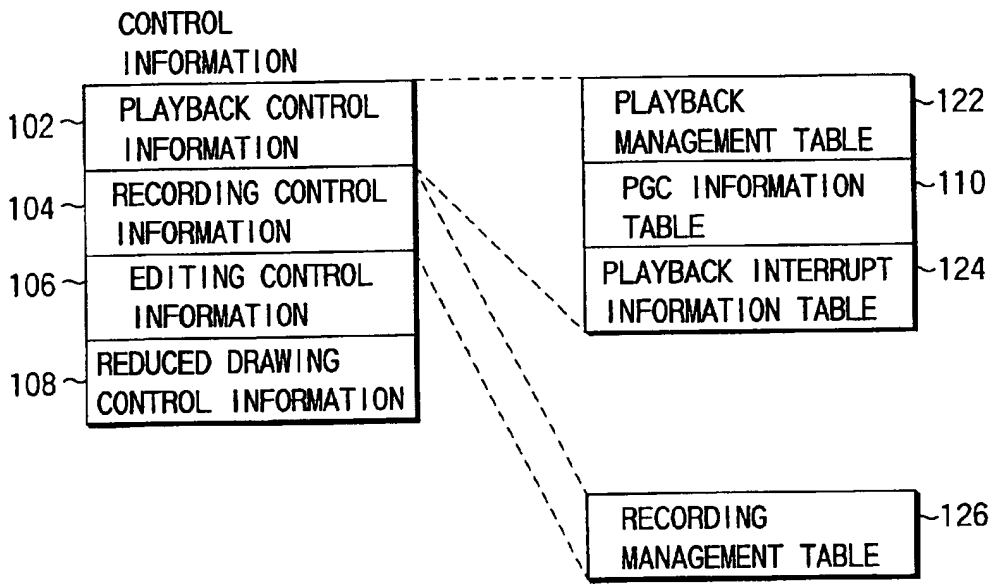
CONTROL INFORMATION
102
PLAYBACK CONTROL INFORMATION
104
RECORDING CONTROL INFORMATION
106
EDITING CONTROL INFORMATION
108
REDUCED DRAWING CONTROL INFORMATION
PLAYBACK MANAGEMENT TABLE
122
PGC INFORMATION TABLE
110
PLAYBACK INTERRUPT INFORMATION TABLE
124
RECORDING MANAGEMENT TABLE
126

FIG. 6

PLY_MAT

RBP		DESCRIPTION	NUMBER OF BYTES
0 TO 11	ID	IDENTIFIER	12 BYTES
12 TO 15	VOBS_SA	START ADDRESS OF VOBS	4 BYTES
16 TO 19	VOBS_EA	END ADDRESS OF VOBS	4 BYTES
20 TO 23	CTLI_EA	END ADDRESS OF CTLI	4 BYTES
24 TO 24	PLYCI_EA	END ADDRESS OF PLYCI	4 BYTES
25 TO 28	CAT	CATEGORY	4 BYTES
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33 TO 34	AST_ATRT	AUDIO STREAM ATTRIBUTE TABLE	2 BYTES
35 TO 36	SPST_Ns	NUMBER OF SUB-PICTURE STREAMS	2 BYTES
37 TO 38	SPST_ATRT	SUB-PICTURE ATTRIBUTE TABLE	2 BYTES
39 TO 39	USER MENU EXIST FLAG	USER MENU PRESENT/ABSENT FLAG 01: FILE PRESENT, 00: FILE ABSENT	1 BYTE
40 TO 40	MAIN PCG NUMBER	PGC NUMBER OF REPRESENTATIVE REDUCED PICTURE	2 BYTES
41 TO 44	RESERVED	RESERVATION	4 BYTES
45 TO 45	PLAY_END FLAG	FLAG FOR PLAYBACK END 0: UNREPRODUCED, 1: REPRODUCED	1 BYTE

FIG. 7

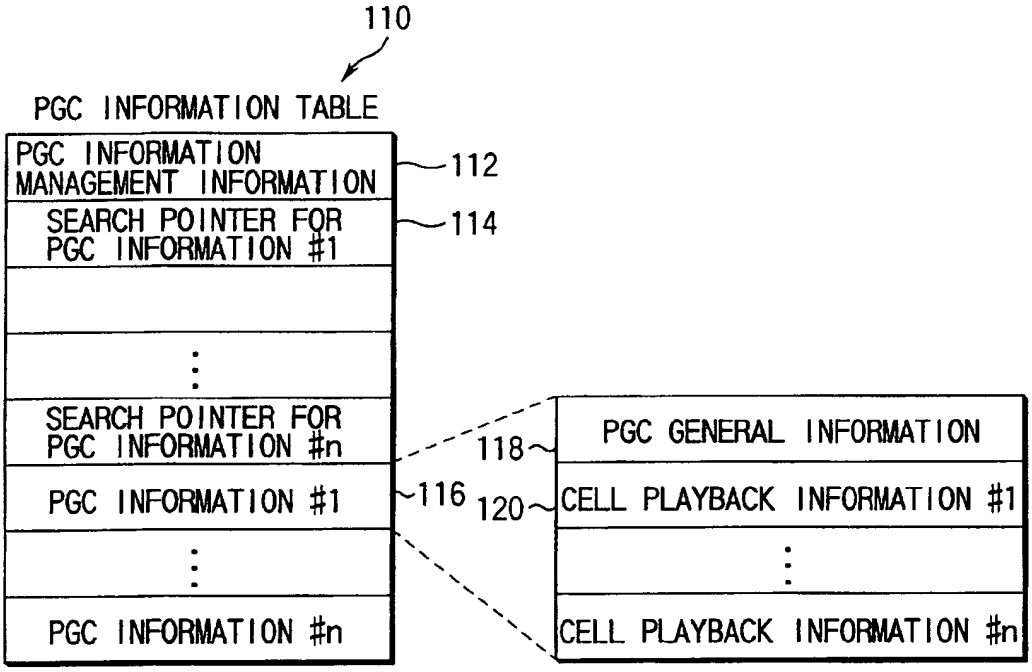
110
PGC INFORMATION TABLE
PGC INFORMATION MANAGEMENT INFORMATION
112
SEARCH POINTER FOR PGC INFORMATION #1
114
SEARCH POINTER FOR PGC INFORMATION #n
PGC INFORMATION #1
116
PGC INFORMATION #n
118
PGC GENERAL INFORMATION
120
CELL PLAYBACK INFORMATION #1
CELL PLAYBACK INFORMATION #n

FIG. 8

PLAYBACK INTERRUPT INFORMATION TABLE

DESCRIPTION	NUMBER OF BYTES
TITLE NUMBER	1 BYTE
PTT NUMBER	1 BYTE
PGC NUMBER	2 BYTES
PROGRAM NUMBER	2 BYTES
CELL ID	2 BYTES
VOBU_ID	2 BYTES
STILL TIME	1 BYTE
STILL REMAINING TIME	1 BYTE
ELAPSED TIME IN CELL	4 BYTES
PLAYBACK TIME	4 BYTES
RECORDING TIME	4 BYTES
TIME INFORMATION FOR TIME SEARCH	4 BYTES
START PTM OF VOBU	4 BYTES
ADDRESS AT WHICH PLAYBACK WAS INTERRUPTED	4 BYTES
AUDIO STREAM NUMBER	1 BYTE
SP STREAM NUMBER & ITS ON/OFF	1 BYTE
GPRM0	2 BYTES
GPRM1	2 BYTES
GPRM2	2 BYTES
GPRM3	2 BYTES
GPRM4	2 BYTES
GPRM5	2 BYTES
GPRM6	2 BYTES
GPRM7	2 BYTES
GPRM8	2 BYTES
GPRM9	2 BYTES
GPRM10	2 BYTES
GPRM11	2 BYTES
GPRM12	2 BYTES
GPRM13	2 BYTES
GPRM14	2 BYTES
GPRM15	2 BYTES

FIG. 9

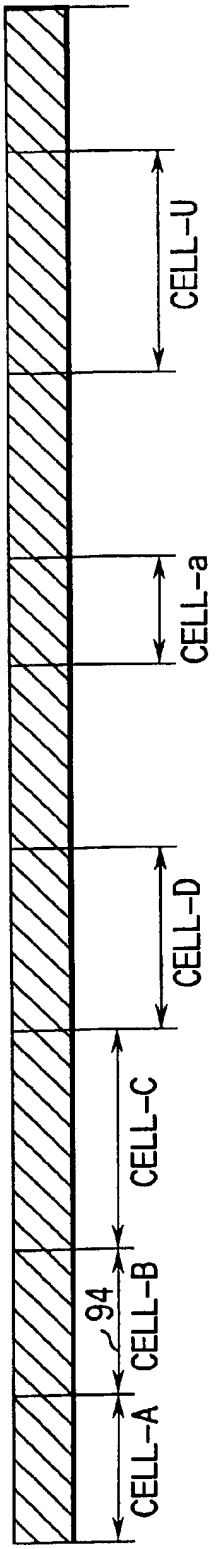

FIG. 10A

PGC#1

NUMBER OF CELLS=3	
#1	CELL-A
#2	CELL-B
#3	CELL-C

FIG. 10B

PGC#2

NUMBER OF CELLS=3	
#1	CELL-D
#2	CELL-E
#3	CELL-F

FIG. 10C

PGC#3

NUMBER OF CELLS=5	
#1	CELL-Q
#2	CELL-R
#3	CELL-S
#4	CELL-T
#5	CELL-U

FIG. 10D

PGC_MAI

RBP		DESCRIPTION	NUMBER OF BYTES
0 TO 3	PGCI_TABLE_EA	END ADDRESS OF PGCI_TABLE	4 BYTES
4 TO 7	PGC_MAI_EA	END ADDRESS OF PGCI_MAI	4 BYTES
8 TO 11	PGC_SRP_SA	START ADDRESS OF PGC_SRP	4 BYTES
12 TO 15	PGC_SRP_EA	END ADDRESS OF PGC_SRP	4 BYTES
16 TO 19	PGCI_SA	START ADDRESS OF PGCI	4 BYTES
20 TO 23	PGCI_EA	END ADDRESS OF PGCI	4 BYTES
24 TO 25	PGC_Ns	TOTAL NUMBER OF PGCs	2 BYTES

FIG. 11

PGC_GI

RBP		DESCRIPTION	NUMBER OF BYTES
0 TO 3	PGC_CNT	CONTENTS OF PGC	4 BYTES
4 TO 7	PGC_PB_TM	PGC PLAYBACK TIME	4 BYTES
8 TO 23	PGC_AST_CTLT	PGC AUDIO STREAM CONTROL TABLE	16 BYTES
24 TO 151	PGC_SPST_CTLT	PGC SUB-PICTURE STREAM CONTROL TABLE	128 BYTES
152 TO 159	PGC_NV_CTL	PGC NAVIGATION CONTROL	8 BYTES
160 TO 223	PGC_SP_PLT	SUB-PICTURE PALETTE TABLE	64 BYTES
224 TO 225	PGC_PGMAP_SA	START ADDRESS OF PROGRAM TABLE	2 BYTES
226 TO 227	CELL_PLY_I_SA	START ADDRESS OF CELL_PLY_I	2 BYTES
228 TO 229	CELL_Ns	NUMBER OF CELLS USED	2 BYTES
230 TO 230	PGC MENU DATA EXIST FLAG	USER MENU DATA PRESENT/ABSENT FLAG 01: DATA PRESENT, 00: DATA ABSENT	1 BYTE
231 TO 234	RESERVED	RESERVATION	4 BYTES
235 TO 235	PLAY_END FLAG	PLAYBACK END FLAG 0: UNREPRODUCED, 1: REPRODUCED	1 BYTE
236 TO 236	ARCHIVE FLAG	PERMANENT STORAGE FLAG 0: FREE, 1: PERMANENT STORAGE	1 BYTE

FIG. 12

CELL_PLY_I

RBP		DESCRIPTION	NUMBER OF BYTES
0 TO 3	C_CAT	CATEGORY OF CELL	4 BYTES
4 TO 7	C_PBTM	PLAYBACK TIME OF CELL	4 BYTES
8 TO 8	PLAY_END FLAG	PLAYBACK END FLAG 0: UNREPRODUCED, 1: REPRODUCED	1 BYTE
9 TO 9	ARCHIVE FLAG	PERMANENT STORAGE FLAG 0: FREE, 1: PERMANENT STORAGE	1 BYTE
10 TO 12	CELL_SA(1072)	START ADDRESS OF CELL	4 BYTES
13 TO 16	CELL_EA(1073)	END ADDRESS OF CELL	4 BYTES

FIG. 13

REC_MAT

RBP		DESCRIPTION	NUMBER OF BYTES
0 TO 3	RECI_EA	END ADDRESS OF RECI	4 BYTES
4 TO 7	REC_MAT_EA	END ADDRESS OF REC_MAT	4 BYTES
8 TO 11	FREE_SPACE	FREE CAPACITY	4 BYTES
12 TO 12	ARCHIVE FLAG	PERMANENT STORAGE FLAG 0: FREE, 1: PERMANENT STORAGE	1 BYTE

FIG. 14

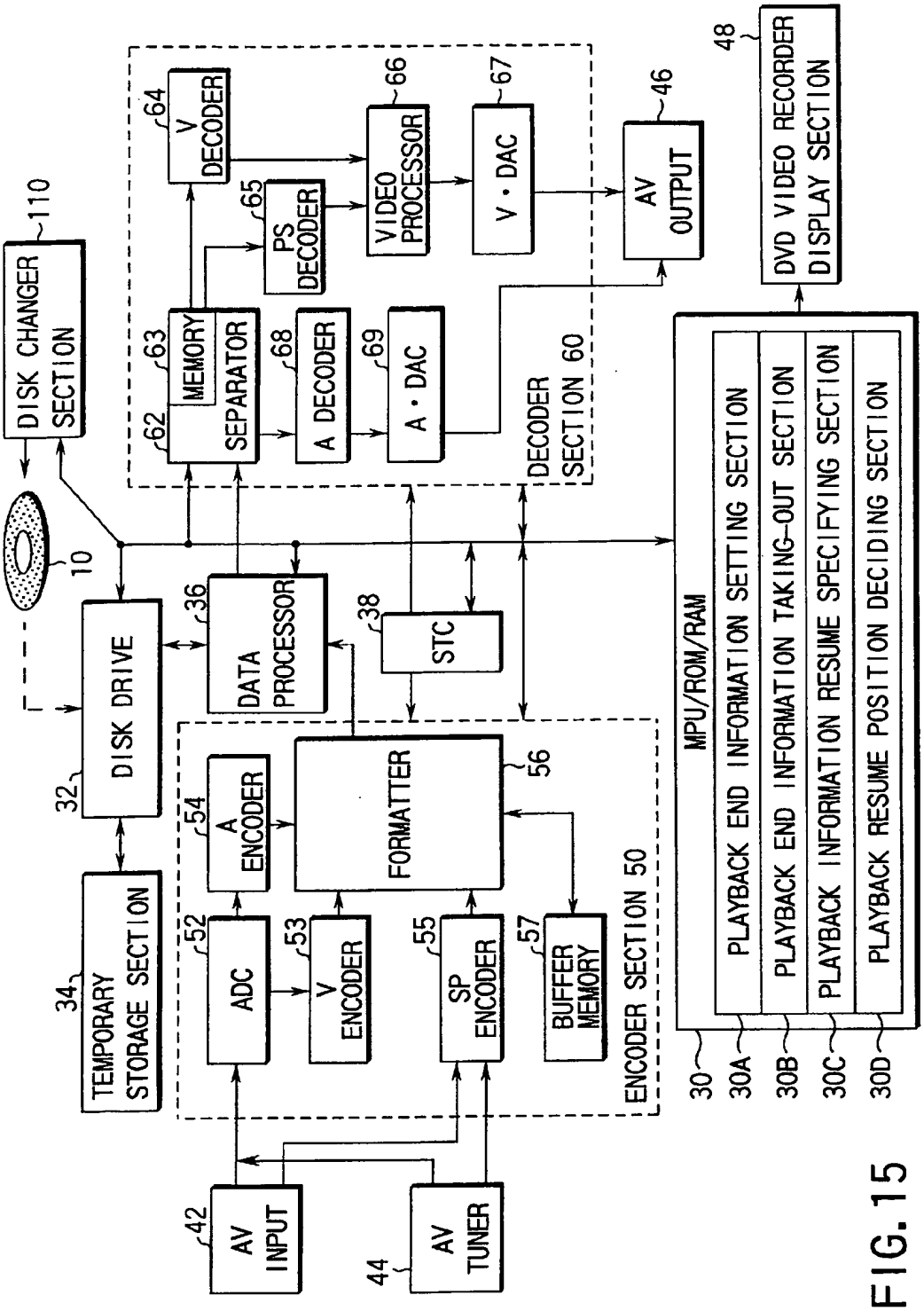
DISK CHANGER SECTION
110
10
DISK DRIVE
32
TEMPORARY STORAGE SECTION
34
DATA PROCESSOR
36
STC
38
DECODER SECTION 60
V DECODER
64
PS DECODER
65
VIDEO PROCESSOR
66
V · DAC
67
AV OUTPUT
46
MEMORY
63
SEPARATOR
62
A DECODER
68
A · DAC
69
DVD VIDEO RECORDER DISPLAY SECTION
48
MPU/ROM/RAM
PLAYBACK END INFORMATION SETTING SECTION
PLAYBACK END INFORMATION TAKING-OUT SECTION
PLAYBACK INFORMATION RESUME SPECIFYING SECTION
PLAYBACK RESUME POSITION DECIDING SECTION
30
30A
30B
30C
30D
ENCODER SECTION 50
A ENCODER
54
FORMATTER
56
ADC
52
V ENCODER
53
SP ENCODER
55
BUFFER MEMORY
57
AV INPUT
42
AV TUNER
44

FIG. 15

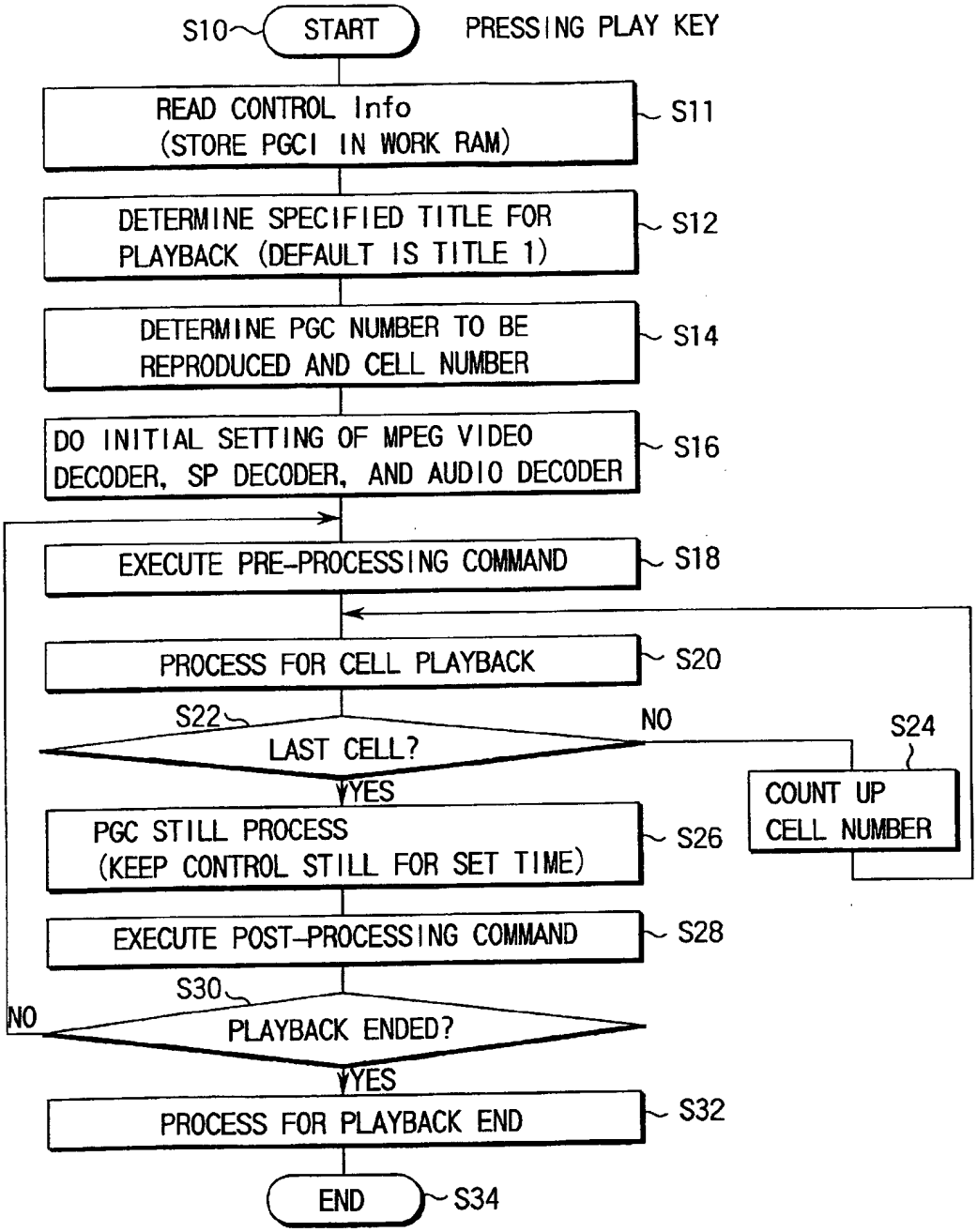
S10
START
PRESSING PLAY KEY
READ CONTROL Info
(STORE PGCI IN WORK RAM)
S11
DETERMINE SPECIFIED TITLE FOR
PLAYBACK (DEFAULT IS TITLE 1)
S12
DETERMINE PGC NUMBER TO BE
REPRODUCED AND CELL NUMBER
S14
DO INITIAL SETTING OF MPEG VIDEO
DECODER, SP DECODER, AND AUDIO DECODER
S16
EXECUTE PRE-PROCESSING COMMAND
S18
PROCESS FOR CELL PLAYBACK
S20
S22
LAST CELL?
NO
S24
COUNT UP
CELL NUMBER
YES
PGC STILL PROCESS
(KEEP CONTROL STILL FOR SET TIME)
S26
EXECUTE POST-PROCESSING COMMAND
S28
S30
NO
PLAYBACK ENDED?
YES
PROCESS FOR PLAYBACK END
S32
END
S34

FIG. 16

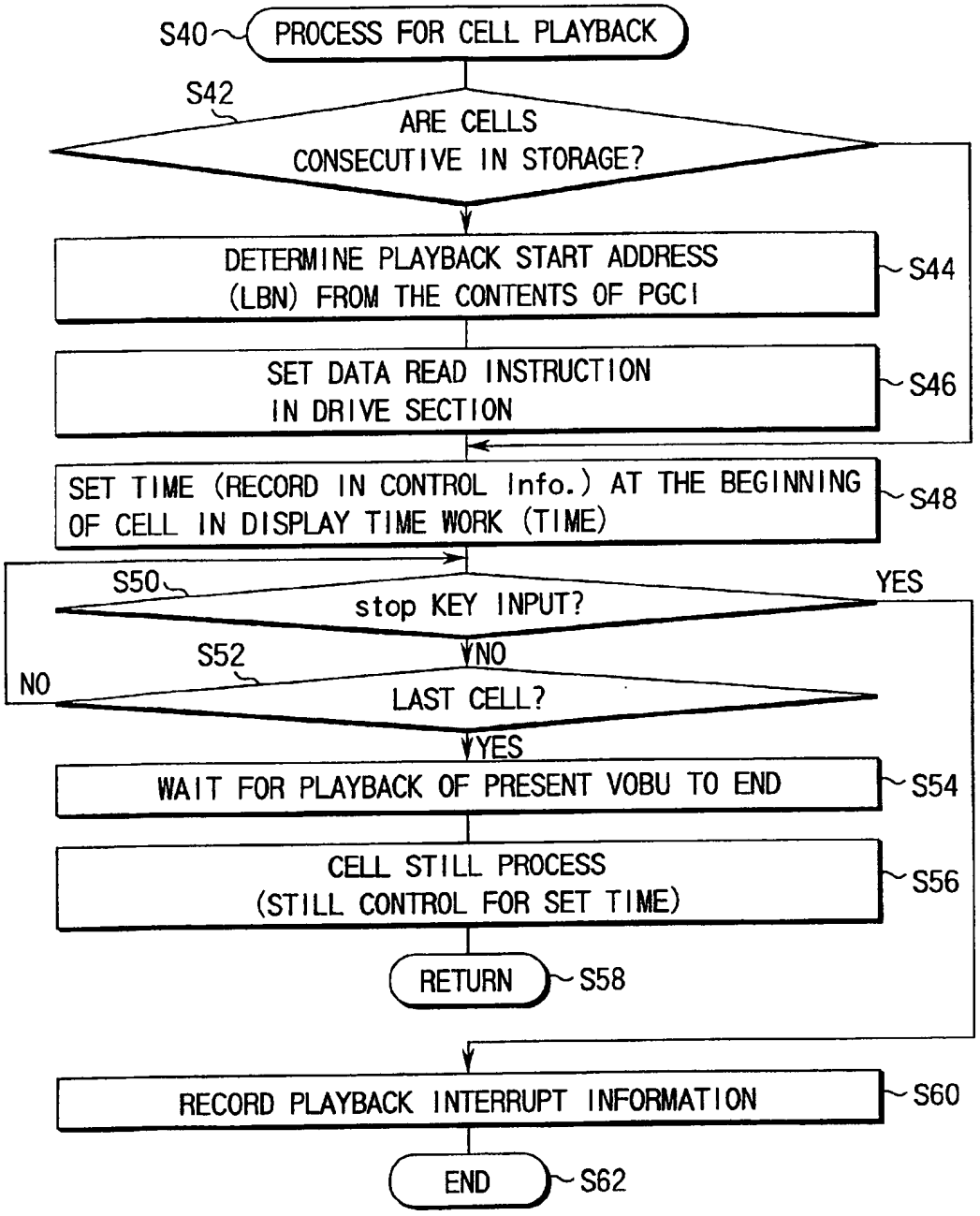
S40
PROCESS FOR CELL PLAYBACK
S42
ARE CELLS CONSECUTIVE IN STORAGE?
DETERMINE PLAYBACK START ADDRESS (LBN) FROM THE CONTENTS OF PGCI
S44
SET DATA READ INSTRUCTION IN DRIVE SECTION
S46
SET TIME (RECORD IN CONTROL Info.) AT THE BEGINNING OF CELL IN DISPLAY TIME WORK (TIME)
S48
S50
stop KEY INPUT?
YES
NO
S52
NO
LAST CELL?
YES
WAIT FOR PLAYBACK OF PRESENT VOBU TO END
S54
CELL STILL PROCESS (STILL CONTROL FOR SET TIME)
S56
RETURN
S58
RECORD PLAYBACK INTERRUPT INFORMATION
S60
END
S62

FIG. 17

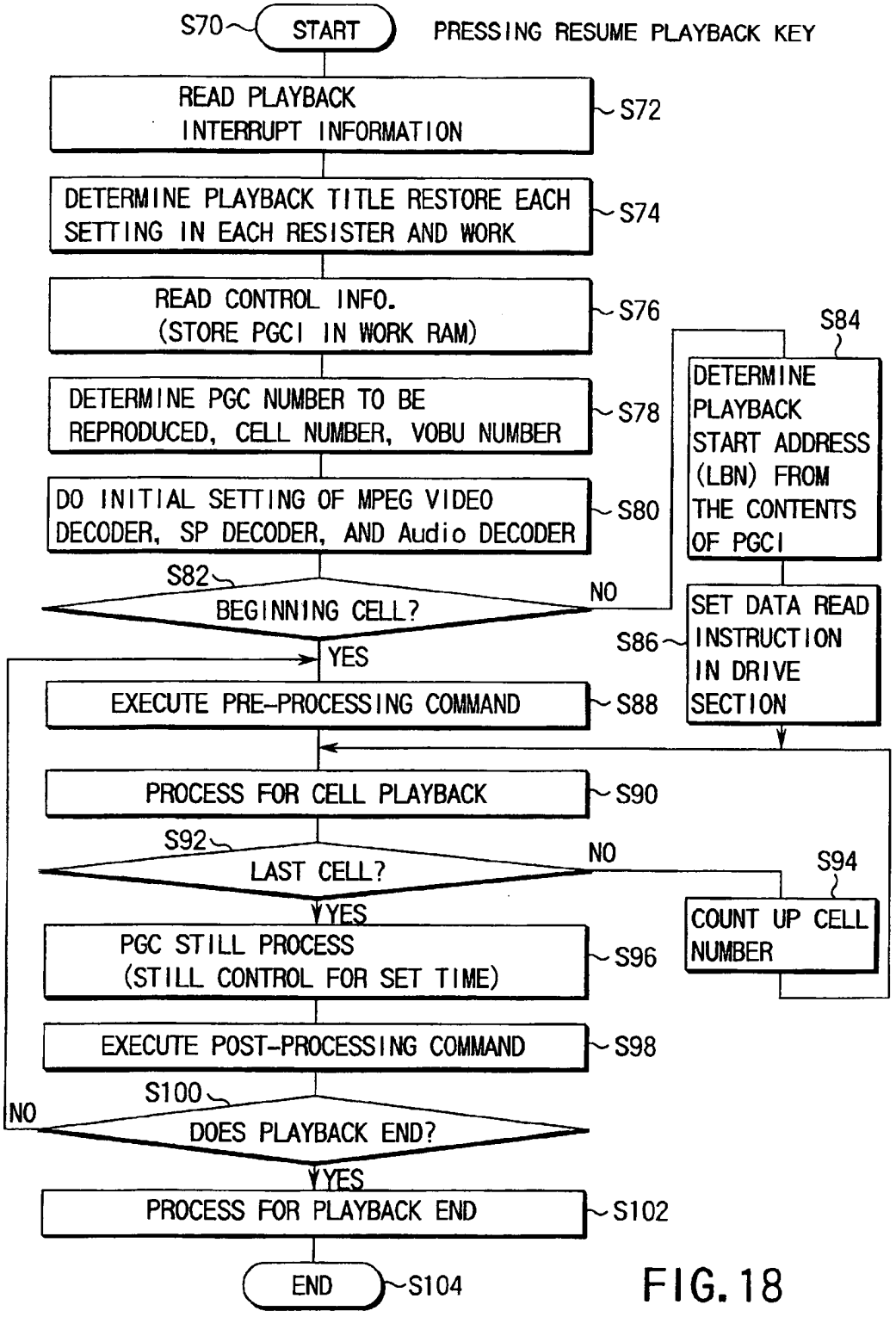
S70
START
PRESSING RESUME PLAYBACK KEY
READ PLAYBACK INTERRUPT INFORMATION
S72
DETERMINE PLAYBACK TITLE RESTORE EACH SETTING IN EACH RESISTER AND WORK
S74
READ CONTROL INFO. (STORE PGCI IN WORK RAM)
S76
DETERMINE PGC NUMBER TO BE REPRODUCED, CELL NUMBER, VOBU NUMBER
S78
DO INITIAL SETTING OF MPEG VIDEO DECODER, SP DECODER, AND Audio DECODER
S80
S82
BEGINNING CELL?
NO
YES
S84
DETERMINE PLAYBACK START ADDRESS (LBN) FROM THE CONTENTS OF PGCI
S86
SET DATA READ INSTRUCTION IN DRIVE SECTION
EXECUTE PRE-PROCESSING COMMAND
S88
PROCESS FOR CELL PLAYBACK
S90
S92
LAST CELL?
NO
YES
S94
COUNT UP CELL NUMBER
PGC STILL PROCESS (STILL CONTROL FOR SET TIME)
S96
EXECUTE POST-PROCESSING COMMAND
S98
S100
DOES PLAYBACK END?
NO
YES
PROCESS FOR PLAYBACK END
S102
END
S104

FIG. 18

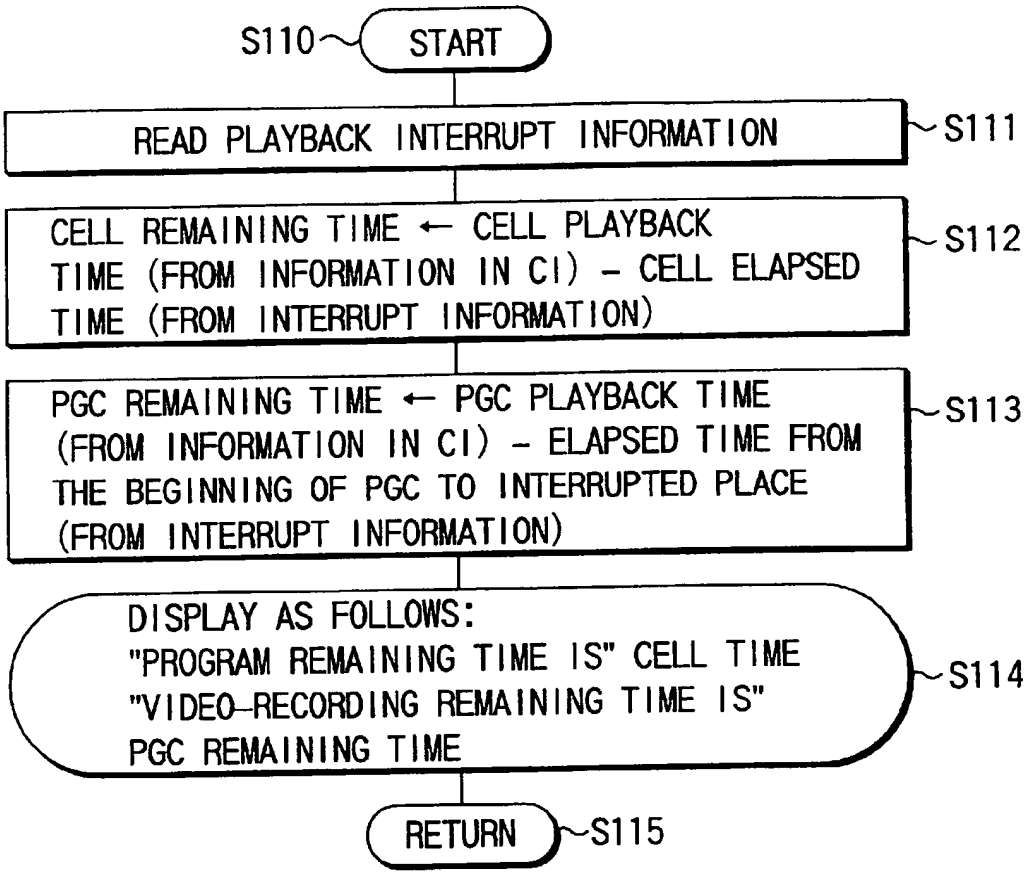
S110
START
READ PLAYBACK INTERRUPT INFORMATION
S111
CELL REMAINING TIME ← CELL PLAYBACK TIME (FROM INFORMATION IN CI) - CELL ELAPSED TIME (FROM INTERRUPT INFORMATION)
S112
PGC REMAINING TIME ← PGC PLAYBACK TIME (FROM INFORMATION IN CI) - ELAPSED TIME FROM THE BEGINNING OF PGC TO INTERRUPTED PLACE (FROM INTERRUPT INFORMATION)
S113
DISPLAY AS FOLLOWS:
"PROGRAM REMAINING TIME IS" CELL TIME
"VIDEO-RECORDING REMAINING TIME IS"
PGC REMAINING TIME
S114
RETURN
S115

FIG. 19

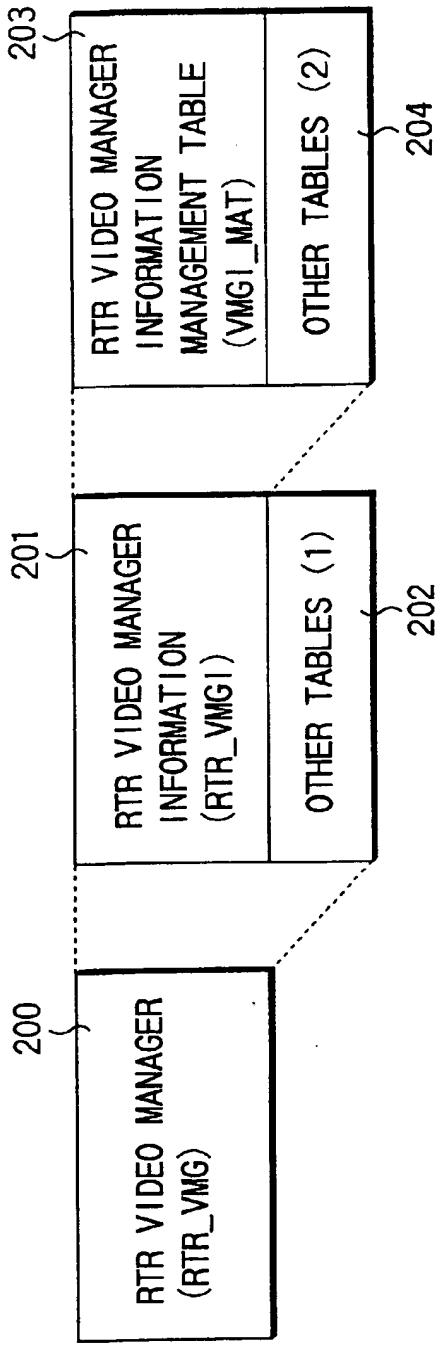

FIG. 20

RSM_MRKI

RBP		DESCRIPTION
134	PGCN	PGC NUMBER
135	PGN	PG NUMBER
136 TO 137	CN	CELL NUMBER
138 TO 143	MRK_PT	MARKER POINTER
144 TO 148	MRK_TM	TIME WHEN MARKING IS DONE

FIG. 21

INFORMATION REPRODUCING SYSTEM, INFORMATION RECORDING/ REPRODUCING SYSTEM, AND RECORDING MEDIUM APPLICABLE TO THE SYSTEM

This is a continuation of Ser. No. 09/582,227 filed Aug. 14, 2000, now abandoned, which is a 371 of PCT/JP99/00211 filed Jan. 21, 1999.

TECHNICAL FIELD

This invention relates to an information reproducing system, an information recording/reproducing system, and a recording medium applicable to the system, and more particularly to a reproducible playback DVD player, a recording/playback DVD player, and an optical disk applicable to these DVD players.

BACKGROUND ART

In recent years, a system for playing back an optical disk on which images (moving pictures), sound, and others have been recorded has been developed. LDS (laser disks) or video CDs (video compact discs) which enable the playback of movie software, karaoke, and the like have been put on the market and widely used.

The DVD standard using the internationally standardized MPEG-2 (Moving Image coding Experts Group) scheme as a moving-picture compression scheme and the AC-3 audio compression scheme as an audio coding mode has been proposed. Optical disks complying with the standard (hereinafter, just referred to as DVD disks) are commercially available and widely used. The DVD standard adopts a moving-picture compression scheme conforming to the MPEG-2 system layers, supports AC-3 audio or MPEG audio as an audio coding mode, and has a data structure including not only a sub-picture pack in which sub-picture data obtained by run-length compressing the bit map data for subtitles has been stored independently but also a navigation pack in which special playback control data, such as fast-forward playback or fast-rewind playback data, has been stored independently in a similar manner. Furthermore, the DVD standard supports ISO 9660 and micro UDF to allow computers to read data.

Presently, the DVD standard has been determined in the form of playback-only formats and therefore is not applicable to home recording/reproducing optical disks and their players. Thus, when recording/reproducing systems for home use are constructed according to the DVD standard, it is clear that the following problems arise. A playback-only DVD video player generally has a resume playback function of, after the interruption of playback, resuming the playback where it was interrupted. Specifically, in the resume playback function, when the playback of the inserted disk has been interrupted, information on the location (address) of the place where playback was just in progress is stored in the RAM in the player, information on the location is accessed, for example, the resume playback key is pressed, or the play key is pressed once to read data on the location where playback was just in progress from the memory, and thereafter, the playback is resumed where it was interrupted, or the play key is pressed again to restart the normal playback.

In the resume playback function in a presently popularized playback-only DVD video player, when the disk is removed, the playback end information on the disk disappears. Even if the same disk is inserted again, it is impossible to resume playback where the playback of the disk was interrupted. This causes a problem: the user himself or herself has to seek the location to be played back. A playback-only DVD video player of the latest model uses an EE-ROM as a memory for storing the playback end information and has the information disk by disk (for example, being capable of storing the playback end information for up to ten disks). Even when the disk is changed, the location to be played back can be searched for.

However, there is a limit to the storage capacity of the memory that uses the method of storing the playback end information. Thus, it is expected that unlimited replacement of disks will make it impossible to search for the playback location.

The DVD player systems have the following problem: when the disk is removed, the playback end information on the disk disappears, and therefore, the user has to seek the playback location, even when the same disk is inserted, to resume playback where it was interrupted.

DISCLOSURE OF INVENTION

An object of the present invention is to provide a disk which enables the interruption of playback where it was interrupted, provided that, after the disk was removed from a playback system capable of recording, the disk is installed again in the system.

Another object of the present invention is to provide an information reproducing system capable of resuming playback where it was interrupted, provided that, after a disk was removed from a system capable of recording, the disk is installed again in the system.

Still another object of the present invention is to provide an information recording/reproducing system capable of resuming playback where it was interrupted, provided that, after a disk was removed from a playback system capable of recording, the disk is installed again in the system.

The foregoing objects are accomplished by providing an information recording medium on which video information, audio information, and others can be recorded, the information recording medium characterized by including an area in which playback interrupt information for resuming playback during the interruption of playback can be recorded.

According to the invention, there is provided an information recording/reproducing system for reproducing video information and audio information from an information recording medium on which video information, audio information, and others can be recorded and which includes a recording area in which playback interrupt information for resuming playback during the interruption of playback can be recorded, the information reproducing system characterized by comprising a specifying section for specifying the resumption of playback and a playback interrupt reading section for reading the playback interrupt information from the recording area according to the specification from the specifying section and in that the system resumes playback where playback was interrupted, according to the specification from the specifying section.

Furthermore, according to the invention, there is provided an information recording/reproducing system for reproducing video information and audio information from an information recording medium on which video information, audio information, and others can be recorded and which includes a recording area in which playback interrupt information for resuming playback during the interruption of playback can be recorded, the information recording/reproducing system characterized by comprising a specifying section for specifying the interruption of playback and a

recording section for recording the playback interrupt information in the recording area according to the specification from the specifying means.

With the information recording/reproducing system of the present invention, since the playback interrupt information has been written on the disk, even when the disk is removed from the system, reinstalling the disk into the system makes it possible to resume playback.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a perspective view to help explain the configuration of an optical disk (DVD-RAM or DVD-RW) that enables recording and reproducing.

FIGS. **2**A and **2**B are diagrams to help explain the data recording area on the optical disk (DVD-RAM) of FIG. **1** and a correlation between the recording tracks for the data recorded in the area and the data recording area.

FIG. **3** is a diagram to help explain the directory structure of the information recorded on the optical disk of FIGS. **1** and **2**.

FIG. **4** shows the data structure of the video object set shown in FIG. **3**.

FIG. **5** shows the structure of a data pack shown in FIG. **4**.

FIG. **6** shows the data structure of the control information shown in FIG. **4**.

FIG. **7** shows the contents of the playback management table (PLY_MAT) shown in FIG. **6**.

FIG. **8** shows the data structure of the PGC information table shown in FIG. **6**.

FIG. **9** shows the contents of the playback interrupt information table shown in FIG. **6**.

FIGS. **10**A, **10**B, **10**C, and **10**D are diagrams to help explain the concept of the PGC shown in FIG. **8**.

FIG. **11** shows the contents of the PGC information management information shown in FIG. **8**.

FIG. **12** shows the contents of the PGC general information shown in FIG. **8**.

FIG. **13** shows the contents of the cell playback information shown in FIG. **8**.

FIG. **14** shows the contents of the recording management table shown in FIG. **6**.

FIG. **15** is a block diagram to help explain the configuration of a system (DVD video recorder) that records and reproduces digital moving-picture information using the information with the structures explained in FIGS. **2** to **14** on the disk of FIG. **1**.

FIG. **16** is a flowchart showing a normal playback operation in the DVD video recorder shown in FIG. **15**.

FIG. **17** is a flowchart showing the process of playing back cells during a normal playback operation in the DVD video recorder shown in FIG. **15**.

FIG. **18** is a flowchart showing a resume playback operation in the DVD video recorder shown in FIG. **15**.

FIG. **19** is a flowchart showing the process of displaying the playback remaining time using the playback interrupt information shown in FIG. **9**.

FIG. **20** is a hierarchical diagram showing a modification of the embodiment of the format shown in FIG. **3**.

FIG. **21** is a table showing the contents of the description of the resume marker information written in the video management information management table shown in FIG. **20**.

BEST MODE FOR CARRYING OUT THE INVENTION

Hereinafter, referring to the accompanying drawings, a digital information recording/reproducing system according to an embodiment of the present invention will be explained.

A typical embodiment of the digital information recording/reproducing system according to the present invention is a system for recording and reproducing the moving pictures encoded on the basis of MPEG 2 at a variable bit rate, such as a DVD video digital recorder.

FIG. **1** is a perspective view to help explain the configuration of a recordable optical disk used for the DVD digital video recorder.

As shown in FIG. **1**, the optical disk **10** is such that two transparent substrates **14**, each provided with a recording layer **17**, are laminated together with an adhesive layer **20**. Each substrate **14** can be composed of 0.6-mm-thick polycarbonate and the adhesive layer **20** can be composed of very thin (for example, 40-μm-thick) ultraviolet-curing resin. The two 0.6-mm-thick substrates **14** are laminated together in such a manner that the recording layers **17** come into contact with the surfaces of the adhesive **20**, thereby forming a 1.2-mm-thick large-capacity optical disk **10**.

In the optical disk **10**, a central hole **22** is made. Around the central hole **22** on both sides of the disk, there are provided clamp areas **24** for clamping the optical disk **10** when it is being rotated. When the optical disk **10** is loaded into a disk drive unit (not shown), the spindle of a disk motor is inserted in the central hole **22**. Then, the optical disk **10** is clamped at the clamp areas **24** by a disk damper (not shown), while it is being rotated.

The optical disk **10** has an information area **25** on which video data, audio data, and other information can be recorded, around the clamp area **24**. In the information area **25**, a lead-out area **26** is provided on its outermost side and a lead-in area **27** is provided on its innermost side in contact with the clamp area **24**. Between the lead-out area **26** and the lead-in area **27**, a data recording area **28** is defined.

On the recording layer (light reflecting layer) **17** in the information area **25**, a recording track is formed continuously in, for example, a spiral. The continues track is divided into physical sectors. These sectors are numbered serially. Using the sectors as units of recording, various types of data are recorded on the optical disk **10**.

The data recording area **28** is an actual data recording area, in which video data (main picture data), such as movies, sub-picture data, such as subtitles or menus, and audio data, such as lines or sound effects, have been recorded as recording/reproducing information in the form of bit trains (which are a physical form or phase change state that causes the reflected laser light to change optically).

When the optical disk **10** is a RAM disk for recording/reproducing, the recording layer **17** can be composed of a triple layer formed by sandwiching a phase change recording material layer (for example, $Ge_2Sb_2Te_5$) between two zinc sulfide.silicon oxide mixtures ($ZnS.SiO_2$).

In the read-only DVD-ROM disk **10**, pit trains are formed in the substrate with a stamper beforehand. On the surface of the substrate **14** in which the pit trains have been formed, a reflecting layer made from, for example, metal, is formed. The reflecting layer is used as the recording layer **17**. In such a DVD-ROM disk **10**, grooves acting as recording tracks are generally not made and the pit trains made at the surface of the substrate **14** function as tracks.

In each of the various types of optical disk **10**, playback-only ROM information is recorded in the recording infor-

mation area of the recording layer **17** in the form of an emboss signal. In contrast, such an emboss signal has not been etched in the recording information area of the substrate **14** having the recording layer **17** for recording and reproducing and instead a continuous groove has been etched. A phase change recording layer has been provided in the groove. In the case of a recording/reproducing DVD-RAM disk, not only the groove but also the phase change recording layer of the land portion is also used for information recording.

The DVD digital video recorder is designed to be capable of the repetitive recording and playback (reading and writing) of a DVD-RAM disk (or DVD-RW disk) and of the repetitive playback of a DVD-ROM disk.

FIGS. **2**A and **2**B are diagrams to help explain the data recording area **28** on the optical disk (DVD-RAM) **10** of FIG. **1** and a correlation between the recording tracks for the data recorded in the area and the data recording area.

When the disk **10** is a DVD-RAM (or DVD-RW), the body of disk **10** is housed in a cartridge **11** to protect the delicate disk surfaces. After the DVD-RAM disk **10**, together with the cartridge **11**, is inserted into the disk drive of the DVD video recorder, explained layer, the disk **10** in the cartridge **11** is clamped to the turn table of the spindle motor and is rotated in such a manner that the disk faces the optical head (not shown).

On the other hand, when the disk **10** is a DVD-R or DVD-ROM, the body of the disk **10** is not housed in a cartridge **11**, the naked disk **10** is set directly on the disk tray of the disk drive.

At the recording layer **17** in the information area **25** shown in FIG. **1**, the data recording track has been formed continuously in a spiral. As shown in FIG. **2**B, the continues track is divided into logical sectors (minimum recording units) with a specific storage capacity. Data is recorded in logical sectors. The storage capacity of one logical sector is set to 2048 bytes (or 2 kilobytes), the same as one pack data length.

The data recording area **28** is an actual data recording area, in which management data, main picture (video) data, sub-picture data, and sound (audio) data have been recorded similarly.

FIG. **3** shows the hierarchical structure of the data recorded on the optical disk **10** acting as an information storage medium that enables the recording and reproducing of the image information and music information shown in FIGS. **1** and **2**.

The data recording area **28** formed on the optical disk **10** shown in FIGS. **1** and **2** has the hierarchical structure of data as shown in FIG. **3**. The logical format of the structure is determined so as to comply with ISO 9660, one of the international standards, and with the universal disk format (UDF) bridge.

As shown in FIG. **3**, the lead-in area **27** is provided on the inner circumference side of the optical disk **10** and the lead-out area **26** is provided on the outer circumference side of the optical disk **26**. The data recording area **28** between the lead-in area **27** and the lead-out area **26** is assigned as a volume space. The volume space **28** includes a space (volume/file management area **70**) for information on the volume and file structure and a space (DVD data area **71**) for applications conforming to the DVD standard.

The lead-in area **27** includes a read-only emboss zone where the optical reflecting surface is uneven, a mirror zone where the surface is a flat mirror, and a rewritable data zone where information can be rewritten. The lead-out area **26** is composed of a rewritable zone that enables information to be rewritten.

In the emboss data zone of the lead-in area **27**, information about the whole information storage medium, including the type of disk, such as DVD-ROM (read-only DVD disk), DVD-RAM (recording/reproducing DVD disk), or DVD-R (postscript-type DVD disk), the disk size, the recording density, and the physical sector numbers indicating the recording start/recording end positions, has been recorded. In addition, information about the recording, reproducing, and erasing characteristics, including the recording power and recording pulse width needed to record the data in the recording layer **17**, the recording power needed to erase the data recorded in the recording layer **17**, the reproducing power needed to reproduce the data recorded in the recording layer **17**, and the linear velocity during recording and erasing, has been recorded. Furthermore, in the emboss data zone of the lead-in area **27**, information on the manufacture of each information storage medium, including the serial number, has been recorded. Each of the rewritable data zone **27** of the lead-in area and the rewritable data zone of the lead-out area includes a recording area for recording a unique disk name for each information storage medium, a checking trial recording area for checking whether recording and erasing can be done under the recording and erasing conditions, and a management information recording area for the presence or absence of a faulty area in the data area **72** and the address of the area. A preparatory process for enabling data to be recorded in the data area **72** is carried out in this area, and the information necessary for subsequent data recording, erasing, and reproducing is recorded.

The volume space **28** is divided physically into a large number of sectors. Those physical sectors are assigned consecutive numbers. The logical addresses for the data recorded in the volume space (data recording area) **28** mean logical sector numbers as determined in ISO 9660 and UDF bridge. The size of the logical sector is set to 2048 bytes (2 kilobytes) as the valid data size of the physical sector.

The logical sector numbers are allocated consecutive numbers in ascending order of the physical sector numbers.

The volume space **28** has a hierarchical structure and includes a volume/file management area **70** and a data area **72** composed of one or more video objects. These areas **70** and **72** are separated on the boundary between logical sectors. One logical sector is defined as containing 2048 bytes. One logical block is also defined as containing 2048 bytes. Therefore, one logical sector is defined as being identical with one logical block.

The volume/file management area **70** is a rewritable data zone in which the user can record and rewrite data and corresponds to a management area determined in ISO 9660 and UDF bridge. On the basis of the description in the area **70**, information about the whole file or volume of audio/video data is stored in the system memory (not shown) in a DVD video recorder explained later. In general, the volume/file management area **70** is composed of one file.

The data area **72** is designed to enable computer data and audio data to be recorded in a mixed manner as shown in FIG. **3**. The order in which computer data and audio and video data are recorded and the size of each recording information are arbitrary. Areas in which computer data has been recorded are referred to as computer data areas **74-1**, **74-2**. An area in which audio and video data has been recorded is referred to as an audio and video data area **76**. When only audio and video data is recorded in the recording

area **72**, the computer data areas **74-1**, **74-2** are not necessarily provided because of their nature. Similarly, when only computer data is recorded in the recording area **72**, the audio and video data area **76** is not necessarily provided because of its nature. Each of the computer data areas **74-1**, **74-2**, and audio and video data area **76** is composed of one or more files.

In the audio and video data area **76**, control information **78** necessary to carry out each of the video recording (audio recording), reproducing, editing, and retrieving processes, and the object to be reproduced, or a video object set **80** composed of one or more video objects **82**, **84**, and **86** as contents, are recorded as shown in FIG. **3**. The video object **80** includes a video object **80** whose content is video data, a picture object **84** whose content is still pictures, such as still slides, the desired location in the video data, or picture data, such as retrieving or editing thumbnails, and an audio object **86** whose content is audio data. Apparently, it is sufficient that the video object set **80** is composed of at least one of these objects **82**, **84**, **86**. It is not necessary to prepare all the objects **82**, **84**, **86**. Similarly, each of the objects **81**, **84**, **86** is composed of one or more files.

In the video object set **80** composed of one or more objects **82**, **84**, **86**, video data (video packs **88** explained later) compressed according to the MPEG standard, audio data (audio packs **90** explained later) compressed according to a specific standard or uncompressed, and run-length-compressed sub-picture data (sub-picture packs **92** including bit maps, explained later, where one pixel is defined by bits) have been stored as shown in FIG. **4**. Apparently, when the video object set **80** is composed of video objects **80**, it has a data structure as shown in FIG. **4**. When the video object set **80** is composed of picture objects **84**, it has a data structure composed of only video packs **88** including no audio pack **90** and/or sub-picture packs. In addition, when the video object set **80** is composed of audio objects **86**, it has a data structure composed of only audio packs **90** including neither a video pack **88** nor a sub-picture pack **92**.

As shown in FIG. **4**, the video object set **80**, or the video, picture, and audio objects **82**, **84**, **86** are logically composed of plural cells **94**. Each cell **84** is composed of one or more video object units (UOBUs) **96**. In the cell **84**, the video object units (VOBUs) **96** are decoded and reproduced in the order in which they are arranged in the cell **84**, as a general rule. Each video object unit **85** is a set (pack train) of video packs (V packs) **88**, sub-picture packs (SP packs) **92**, and audio packs (A packs) **90** and is defined as data to be reproduced in a period of, for example, 0.5 to 1.2 seconds. These packs are minimum units in performing data transfer. The data is processed using logical cells as minimum units. The video object units (VOBUs) are assigned identification numbers (IND#k; k=0 to k). The identification numbers enable the video object units **96** to be identified. The playback period of the video object unit **96** generally corresponds to the playback time of the video data composed of one or more picture groups (groups of pictures; abbreviated as GOPs) included in a video object unit (VOBU) **85**. One GOP generally lasts for about 0.5 second in the MPEG standard and is converted into screen data compressed so as to reproduce about 15 frames of pictures in about 0.5 second.

When the video object unit VOBU **96** includes video data, GOPs (conforming to the MPEG standard) composed of video packs **88**, sub-picture packs **90**, and audio packs **91** are arranged, thereby forming a video data stream. Even when playback data is composed of only audio and/or sub-picture data, it is constructed using a video object unit (VOBU) **96** as one unit. For example, the video object unit (VOBU) **85** may be composed of only audio data. In this case, as with the video object VOB including video data, the audio packs **90** to be reproduced during the playback time of the video object unit (VOBU) **85** to which the audio data belongs are stored in the video object unit (VOBU) **96**.

The video objects **82**, **84**, **86** constituting the video object set **80** are assigned identification numbers (IND#i; i=0 to i). The identification numbers enable the video objects **82**, **84**, **86** to be identified. Like the video objects **82**, **84**, **86**, each cell **94** is assigned an identification number (C_IDN#j).

FIG. **5** shows a general structure of the video pack **88**, sub-picture pack **92**, and audio pack **90**. Like the logical sector of FIG. **2**, each of these packs contains 2048 bytes of data. Each of the video, audio, and sub-picture packs **88**, **90**, **92** is composed of a pack header **98** and a packet **100** as shown in FIG. **5**. The packet **100** includes a packet header. In the packet header, a decode time stamp (DST) and a presentation time stamp (PTS) have been recorded.

The control information shown in FIG. **3** includes playback control information **102** indicating control information necessary for playback, recording control information **104** indicating control information necessary for recording (video recording and audio recording), editing control information **106** indicating control information necessary for editing, and thumbnail picture control information **108** indicating management information about searching or editing thumbnails for locations in the video data the user wants to watch.

The playback control information **102** shown in FIG. **3** includes a management information table (PLY_MAT) **122**, a program chain (PGC) information table (PGC IT) **110**, and a playback interrupt information table (PLY_IIT) **124** as shown in FIG. **6**. In the management information table (PLY_MAT) **122**, the information as shown in FIG. **7** has been written. The program chain (PGC) information table **110** has a data structure as shown in FIG. **8**. In the playback interrupt information table **124**, the information as shown in FIG. **9** has been written.

As shown in FIG. **8**, the PGC information table **110** is composed of PGC information management information **112**, search pointers **#1** to **#n** **114** for searching for each piece of PGC information, and pieces of PGC information **#1** to **#n** **116**. In the program chain (PGC) information table **110**, information about the order in which program chains (PGCs) and cells are reproduced. The data in the cells **94** recorded in the video object **82**, that is, the movie data, the actual data, composed of video object units **96**, is reproduced according to the description in the program chain (PGC) information table **110**. The program chain (PGC) information table **110** is composed of PGC information management information **112**, PGC information **#1** to PGC information **#n**, and search pointers **114** for searching for the PGC information (**#1**) **116** for PGC information (**#n**) **116**. Once the number of PGC has been determined, the cell playback sequence to reproduce the PGC corresponding to the number of the PGC is acquired by referring to the search pointer **114**. According to the cell playback sequence, the data in the cell **94** as real data is acquired from the video object **82** and the video is played back. The video object **82** has been explained until now. Similarly, the cell data as real data is taken out from the picture object **84** and audio object **86** according to the description in the program chain (PGC) information table **110** and is reproduced.

The PGC corresponds to a chapter in a movie story and represents a unit for executing a series of playback where the cell playback sequence has been specified. In other words,

when one PGC is likened to one drama, the cells **94** constituting the PGC can be interpreted as corresponding to various scenes in the drama. The contents of the PGC (or the contents of the cells) are determined by the software provider that creates the contents recorded on the disk **10**. Specifically, when there is a video data stream as shown in FIG. **10**A, the contents are divided into video object units **96** to be reproduced in a certain period of time. A set of video object units **96** consecutive in principle is defined as a cell **94**.

Because the video object units **96** are consecutive in principle, the cell **94** is defined by the first video object unit **96** and last video object unit **96** constituting the cell in the PGC information **116**, more particularly, the cell playback information **120**, as explained later. Namely, in the cell playback information **120**, information on the playback section specified by the start address and end address of the playback data constituting the cell is written.

Once the cells **94** have been determined, a PGC is constructed by determining the playback sequence of the cells. For example, as shown in FIGS. **10**B, **10**C, and **10**D, three cells **96** are arranged in a cell playback information table in such a manner that cell-A, cell-B, and cell-B are reproduced in that order, thereby defining PGC#1. Similarly, three cells **96** are arranged in the cell playback information table in such a manner that cell-D, cell-E, and cell-F are reproduced in that order, thereby defining PGC#2. Furthermore, five cells **96** are arranged in the cell playback information table in such a manner that cell-Q, cell-R, cell-S, cell-T, and cell-U are reproduced in that order, thereby defining PGC#3. Here, linking PGC#1 and PGC#2 together enables PGC#1 corresponding to a certain chapter to be played back, followed by the playback of PGC#2 corresponding to the next chapter. In other words, cell-A to cell-F are reproduced consecutively. In the PGC, the cells **94** are reproduced in the order of arrangement. Because the way of constructing the PGC and the playback sequence of the PGC are arbitrary, for example, a PGC can be defined by the cells constituting another PGC. In addition, the way of linking, or link information, can be determined arbitrarily, various stories can be created or edited. For example, PGC#3 can be linked, following PGC#1. Adding the same cell, for example, cell G, to PGC#1 and PGC#2 can create a different chapter. The user can make a selection to link PGC#3 to PGC#1 or PGC#2, thereby reproducing any story.

As shown in FIG. **7**, in the playback management table **122**, an identifier ID indicating playback control information is written. In addition, the start address (VOBS_SA) and end address (VOBS_EA) of the video object set **80** are written. Moreover, the end address (CTLI_EA) of control information (CTLI) **102** and the end address (PLYI_EA) of the playback control information (PLYI) **102** are written. Furthermore, in the playback management table **122**, an attribute (CAT) indicating that the management information belongs to a recording/reproducing DVD format is written. In addition, the attribute of the video in the video object set recorded in the audio and video data area **76**, such as, the NTSC system or wide, is written. Moreover, the number (ATS_Ns) of audio streams in the similarly recorded video object set and a table (AST_ATR) describing its attribute, for example, the compression scheme, are written. Furthermore, the number (SPST_Ns) of sub-picture streams in the similarly recorded video object set and a table (SPST_ATR) describing its attribute and others are written. When the user has recorded menu picture data and moving-picture or still-picture data in the form of independent files in the audio and video data area **76**, if a flag (01) indicating the presence of a user menu or such a menu does not exist, a flag (00) indicating that there is no user menu is written. When a reduced picture has been recorded in the audio and video data area **76**, the number of the PGC representing the reduced picture and constituting the basis of the reduced picture is written. In addition, a flag (0: unreproduced, 1: reproduced) indicating whether or not the user has played back the video object set to be reproduced according to reservation and control information **78** is written.

The PGC information management information (PGC_MAI) **112** shown in FIG. **8** includes information indicating the number of PGCs as shown in FIG. **11**. The PGC information search pointer **114** includes information pointing at the head of each piece of PGC information as described earlier, making it easier to search for a PGC. The PGC information **116** is composed of PGC general information **118** shown in FIG. **7** and one or more pieces of cell playback information **120** shown in FIG. **8**.

Written in the PGC information management information **112** (PGC_MAI) as shown in FIG. **11** are the end address (PGC_TABLE_EA) of the PGC information table **110**, the end address (PGC_MAI_EA) of PGC information management information **112** (PGC_MAI), the start address (PGC_SRP_SA) and end address (PGC_SRP_EA) of the PGC information search pointer (PGC_SRP) **114**, the start addresses (PGCI_SA) and end addresses (PGCI_EA) of all the pieces of PGC information (PGCI) **116**, and the number of all the PGCs (PGC_Ns).

The PGC general information (PGC_GI) **118** includes information indicating the playback time of PGC and the number of cells as shown in FIG. **12**. Specifically, written in the PGC general information (PGC_GI) **118** are the number of the PGCs, the contents (PGC_CNT) of the PGC describing the number of cells, the playback time (PGC_PB_TM) of the PGCs, a table (PGC_AST_CTL) describing information to control the audio streams included in the PGCS, and a table (PGC_SPST_CTL) describing information to control the sub-picture streams included in the PGCs. Furthermore, written in the PGC general information (PGC_GI) **118** are link information about a PGC to be linked with the PGC, for example, PGC navigation control (PGC_NV_CTL) describing the preceding PGC, the following PGC, or the (Goup) PGC at the jump destination, a sub-picture pallet table (PGC_SP_PLT) describing reproduction information on the colors on the sub-picture pallet and others, and the start address (PGC_PGMAP_SA) of a program table (not shown) listing the programs constituting the PGC. In addition, written in the table (PGC_GI) are the start address of cell playback information (CELL_PLY_I) **120**, a flag (01: menu data present, 00: menu data absent) indicating whether or not the user-created menu data on the PGCs is present, reservation, a flag (0: unreproduced, 1: reproduced) indicating whether the user has reproduced the PGCS, and a flag (ARCHIVE Flag) indicating whether or not the user wants to continue storing the PGCs, or a flag (0: free [erasable], 1: permanent storage) indicating that the user wants to store the PGCs forever.

In the cell playback information (CELL_PLY_I) **120** shown in FIG. **8**, the category of a cell (C_CAT), for example, whether the cell belongs to a block, and if it belongs to the block, whether the block is an angle block, is written as shown in FIG. **13**. Furthermore, in the cell playback information (CELL_PLY_I) **120**, the playback time (absolute time) of the cells in the PGC, a flag (0: unreproduced, 1: reproduced) indicating whether the user has reproduced the cell, and a flag (ARCHIVE Flag) indicating whether or not the user wants to continue storing the

cell, or a flag (0: free [erasable], 1: permanent storage) indicating that the user wants to store the cell forever. Moreover, in the cell playback information (CELL_PLY_I) **120**, the start address (CELL_SA) and end address (CELL_EA) of the cell and the addresses of the first and last video object units (VOBUs) in the cell are written using relative addresses counted from the beginning of the video object set **80**.

The angle block means a block that enables the angle to be switched. Angle switching means changing the angle (camera angle) at which the picture of the subject is viewed. In an example of rock concert video, it means that the user can watch scenes taken at various angles, including a scene focusing on the vocalist, a scene focusing on the guitarist, and a scene focusing on the drummer.

The cases where angle switching (or angle changing) is done include a case where angle can be selected according to the liking of the viewer and a case where the same scene is repeated automatically in the flow of the story, while the angle is being changed (a case where the software creator/provider has composed the story that way or a case where the user of the DVD video recorder has edited the story that way).

The playback interrupt information table **124** of FIG. **6** is a table in which the playback interrupt information to be written when the user interrupts the playback is written. As shown in FIG. **9**, in the table **124**, all of or part of the following items are written at the time of the interruption of the playback: the title number of the title whose playback has been interrupted, the part-of-title number at which the playback has been interrupted, the PGC number at which the playback has been interrupted, the program number in the PGC whose playback has been interrupted, the cell ID whose playback has been interrupted, and the ID of the video object unit whose playback has been interrupted. The title corresponds to a concrete title composed of video objects. The video objects are managed on a title basis. When the user subdivides a title and specifies part of the title, a part-of-title number is assigned and the number is recorded as interrupt information. When the user is a music fan, he or she can record a program for a singer and specify a scene of a special song in the program as part of title. Information on the scene is recorded as interrupt information. Furthermore, when the playback picture is a still picture, the time the still picture lasts and the remaining time of the still picture during the interruption of the playback are written. In addition, the elapsed time in reproducing a cell is written as interrupt information. Moreover, the time during the interruption of the playback and the recording time when the reproduced object is recorded are recorded. Still furthermore, time search time information to determine the time of interruption in the video object set (VOBS) or video object (VOB) temporally, a presentation time stamp representing the time at which the interrupted video object unit (VOBU) **96** is presented, and the address at which the playback was interrupted, for example, the video object unit (VOBU) **96** or the physical sector address on the optical disk at which the playback was interrupted, and others are written. In addition, recorded in the playback interrupt information table **124** are whether or not the audio stream number and sub-picture stream at the time of interruption have been selected (whether or not the sub-picture should be displayed) and the sub-picture stream number at the time of the interruption when the sub-picture stream has been selected and the sub-picture has been displayed. Moreover, if necessary, predetermined general parameters (GPRM **0** to GPRM **15**) are written.

The general parameters (GPRM **0** to GPRM **15**) cause the details of the operation the user has carried out to be stored in memory and change the operation of the player on the basis of the details. The contents written as interrupt information in the playback interrupt information table **124** may include not only the items shown in FIG. **9** but also additional items, as the need arises. Moreover, among the items shown in FIG. **9**, the necessary minimum items may be recorded. While the playback interrupt information table **124** have been provided as an independent file at the same level of hierarchy as that of the playback management table **122** as shown in FIG. **6**, it may be provided in the playback management table **122**. Alternatively, it may be provided at a higher level of hierarchy than that of the playback management table **122**. For instance, it may be provided at the same level of hierarchy as that of the playback control information **102** or that of the control information **78**.

The recording control information **104** of FIG. **6** includes a recording management table **126** shown in FIG. **14**. In the recording management table **126**, the end address (RECI_EA) of the recording control information **104** and the end address (REC_MAT_EA) of the recording management table **126** are written. An empty area (FREE_SPACE) in which information on recording management is to be written is provided in the recording management table **126**. Furthermore, in the recording management table **126**, a flag (ARCHIVE Flag) indicating whether or not the user wants to store all the VOBS, or a flag (0: free [erasable], 1: permanent storage) indicating that the user wants to store all the VOBS forever.

FIG. **15** shows an example of the configuration of a system (DVD video recorder) which records and reproduces the digital moving-picture information on and from the disk of FIG. **1** at a variable recording rate using the pieces of information having the structures explained in FIGS. **3** to **14**.

The body of the DVD video recorder shown in FIG. **14** is roughly composed of a disk drive section (**32**, **34**, and others) that rotates a DVD-RAM or DVD-R disk **10** and reads and writes information from and on the disk **10**, an encoder section **50** constituting the video recording side, a decoder section **60** constituting the playback side, and a microcomputer block **30** for controlling the operation of the body of the system.

The encoder section **50** includes an ADC (analog/digital converter) **52**, a video encoder (V encoder) **53**, an audio encoder (A encoder) **54**, a sub-picture encoder (SP encoder) **55**, a formatter **56**, and a buffer memory **57**.

The external analog video signal+external analog audio signal from an AV input section **42** or the analog TV signal+analog audio signal from a TV tuner **44** are inputted to the ADC **52**. The ADC **52** digitizes the inputted analog video signal at, for example, a sampling frequency of 13.5 megahertz, with the number of quantization bits being eight bits. (That is, each of the luminance component Y, color difference component Cr (or Y-R), and color difference component Cb (or Y-B) is quantized in eight bits.)

Similarly, the ADC **52** digitizes the inputted analog audio signal at, for example, a sampling frequency of 48 kilohertz, with the number of quantization bits being 16 bits.

When the analog video signal and digital audio signal are inputted to the ADC **52**, the ADC **52** allows the digital audio signal to pass through. (Only jitters incidental to the digital signal may be reduced or the sampling rate or the number of quantization bits may be changed without changing the contents of the digital audio signal.)

On the other hand, when the digital video signal and digital audio signal are inputted to the ADC **52**, the ADC **52**

allows the digital video signal and digital audio signal to pass through. (As for these digital signals, too, the jitter reducing process, the sampling rate changing process, and others may be carried out without changing the contents of the digital signal.)

The digital video signal component from the ADC **52** is sent to the formatter **56** via the video encoder (V encoder) **53**. The digital audio signal component from the ADC **52** is sent to the formatter **56** via the audio encoder (A encoder) **54**.

The V encoder **53** has the function of converting the inputted digital video signal into a digital signal compressed at a variable bit rate on the basis of the MPEG-2 or MPEG-1 standard.

The A encoder **56** has the function of converting the inputted digital audio signal into a digital signal (or a linear PCM digital signal) compressed at a fixed bit rate on the basis of the MPEG or AC-3 standard.

When the DVD video signal having a data structure as shown in FIGS. **4** and **5** (for example, the signal from the DVD video player with an independent output terminal for sub-picture signal) is inputted from the AV input section **42**, or when the DVD video signal having such a data structure is broadcast and received by the TV tuner **44**, the sub-picture signal component (sub-picture pack) in the DVD video signal is inputted to the sub-picture encoder (SP encoder) **55**. The sub-picture data inputted to the SP encoder **55** is arranged into a specific signal form. The resulting data is sent to the formatter **56**.

The formatter **56** performs specific signal processes on the inputted video signal, audio signal, sub-picture signal, and others, while using the buffer memory **57** as a work area, and outputs to the data processor **36** the recording data that coincides with the format (file structure) as explained in FIGS. **3** to **25**.

Here, the contents of a standard encoding process for creating the recording data will be explained briefly. When the encode section **50** of FIG. **15** starts the encoding process, the parameters necessary to encode the video (main picture) data and video data are set. Next, using the set parameters, the main picture data is preencoded and the distribution of the optimum amount of codes for the set average transfer rate (recording rate) is calculated. On the basis of the amount of codes obtained in the preencoding, the main picture is encoded. At this time, the audio data is encoded at the same time.

In a case where the amount of data compression is insufficient as a result of pre-encoding (a case where the desired video program cannot fit to a DVD-RAM disk or DVD-R disk on which the user is going to record the program), if there is a chance to do pre-encoding (for example, if the video recording source is a repeatedly reproducible source, such as a videotape or a video disk), part of the main picture data is encoded again and the main picture data in the reencoded part is replaced with the pre-encoded main picture part. By such a series of processes, the main picture data and audio data are encoded, thereby remarkably reducing the value of the average bit rate necessary for recording.

Similarly, the parameter necessary to encode the sub-picture data is set and the encoded sub-picture data is created.

The encoded main picture data, audio data, and sub-picture data are combined so as to have the structure of the video object.

Specifically, a cell is set as the minimum unit of the main picture data (video data) and cell playback information (C_PLY_I) as shown in FIG. **13** is created. Next, the structure of a cell constituting a program chain (PGC) and the attributes of main picture, sub-picture, and audio, and others are set (pieces of information obtained in encoding each data item are used as part of the attribute information), thereby creating the playback control information **102** including various types of information explained in FIGS. **3** and **6**.

The encoded main picture data, audio data, and sub-picture data are subdivided into packs of a specific size (2048 bytes) as shown in FIG. **5**. In these packs, time stamps, including PTS (presentation time stamps) and DTS (decode time stamps), are written. As PTS for sub-pictures, the time obtained by arbitrarily delaying the PTS for the main picture data or audio data in the same playback time zone may be written.

Then, the packs are arranged into VOBUs **96**, the data to be reproduced in a certain period of time, in such a manner that they can be reproduced in the order of the time codes of the respective data. The VOBUs **96** are arranged, thereby defining each data cell. Then, cells constitute a VOB. A VOBS **80** composed of one or more VOBs is formatted into the structure of FIG. **4**.

The disk drive section for reading and writing (video-recording and/or reproducing) information from and on the DVD disk **10** includes a disk changer section **110**, a disk drive **32**, a temporary storage section **34**, a data processor **36**, and a system time counter (or system time clock STC) **38**.

The temporary storage section **34** is used to buffer a certain amount of the data (the data outputted from the encoder section **50**) written onto the disk **10** via the disk drive **32** or a certain amount of the data (the data inputted to the decoder section **60**) reproduced from the disk **10** via the disk drive **32**.

For example, when the temporary storage section **34** is composed of 4-megabyte semiconductor memory (DRAM), it is possible to buffer about eight seconds of recording or playback data at an average recording rate of 4 mbps. In addition, when the temporary storage section **34** is composed of a 16-megabyte EEPROM (flash memory), it is possible to buffer about 30 seconds of recording or playback data at an average recording rate of 4 mbps. Furthermore, when the temporary storage settion **34** is composed of a 100-megabyte ultraminiature HDD (hard disk), it is possible to buffer longer than three minutes of recording or playback data at an average recording rate of 4 mbps.

When the disk **10** has run short in the course of video-recording, the temporary storage section **34** can be used to store the video-recording information until the disk **10** has been replaced with a new one.

Furthermore, when a high-speed drive (double-speed or faster one) is used as the disk drive **32**, the temporary storage section **34** can be used to store the extra data read from an ordinary drive in a specific period of time. Buffering the read data during playback in the temporary storage section **34** prevents the playback image from being interrupted, even when the optical pickup (not shown) has made reading errors due to vibrations or shocks, because the playback data buffered in the temporary storage section **34** is used instead.

Under the control of the microcomputer block **30**, the data processor **34** of FIG. **14** supplies the DVD recording data from the encoder section **50** to the disk drive **32**, takes out the DVD playback signal reproduced from the disk **10** from the drive **32**, rewrites the management information recorded on the disk **10**, and deletes the data (files or VTS) recorded on the disk **10**.

The microcomputer block **30** includes an MPU (or CPU), a ROM in which control programs and others have been written, and a RAM that offers a work area necessary to execute programs.

The MPU of the microcomputer block **30** uses the RAM as a work area according to the control programs stored in the ROM and functions as if it had a playback end information setting section **30A** for determining playback end information, a playback end information takeout section **30B** for taking out playback end information, a playback information resume specifying section **30C** for giving an instruction to resume playback using the playback information, and a playback resume position deciding section **30D** for determining the position at which playback is resumed.

Of the results of the execution of the MPU **30**, the contents to be reported to the user of the DVD video recorder are displayed on the display section **48** of the DVD video recorder and or on the on-screen display (OSD) of the monitor display.

The timing with which the MPU **30** controls the disk changer section **100**, disk drive **32**, data processor **36**, encoder section **50** and/or decoder **60** can be executed on the basis of the time data from the STC **38** (the operation of video-recording and reproducing is generally executed in synchronization with the time clock from the STC **38**. The other processes may be executed with the timing independent from the STC **38**).

The decoder section **60** includes a separator **62** for separating and taking out each pack from the DVD playback data having a pack structure as shown in FIG. **5**, a memory **63** used in executing pack separation and other signal processes, a video decoder (V decoder) **64** for decoding the main picture data separated by the separator **62**, a sub-picture decoder (SP decoder) **65** for decoding the sub-picture data (the contents of the sup-picture pack **90**) separated by the separator **62**, an audio decoder (A decoder) **68** for decoding the audio data (the contents of the audio pack **91** of FIG. **9**) separated by the separator **62**, a video processor **66** for combining the video data from the V decoder **74** with the sub-picture data from the SP decoder **65** suitably and superposing sub-pictures, including a menu, highlight buttons, and subtitles, on the main picture, a video digital/analog converter (V.VAC) **67** for converting the digital video output from the video processor **66** into an analog video signal, and an audio digital/analog converter (A.DAC) **67** for converting the digital audio output from the A decoder **68** into an analog audio signal.

The analog video signal from the V.DAC **67** and the analog audio signal from the A.DAC **67** are supplied via the AV output section **46** to an external component (not shown) (a multichannel stereo system with two to six channels+ monitor TV or projector).

The data processing operation, that is, the video-recording and reproducing processes, in the above recording/reproducing system (DVD video recorder) will be explained.

In data processing during video-recording, when the MPU section **30** receives a video-recording instruction as a result of the user's key input, the necessary management data is read from the DVD disk **10** from the disk drive section **32** and an area to be written into is determined. Next, setting is done in the management area so that the recording data may be written in the determined area. The write start address for the video data is set in the drive section **32**, thereby preparing to record the data.

The management area that is set indicates a file management section (directory code in ISO 9660) and control information **78**. The necessary parameters are recorded in the file management section.

Next, the MPU **32** resets the time in the STC section **38**. At this time, the STC section **38** effects video-recording and reproducing on the basis of the value in the timer of the system. Thereafter, the MPU section **30** implements setting in each of the other sections.

The flow of the video signal is as follows. The AV signal supplied from the TV tuner section **44** or by an external input is A/D converted by the ADC **52**. The picture signal is inputted to the video encode section **53**, the audio signal is inputted to the audio encode section **54**, and the TV tuner section **44** inputs a closed caption signal or a text signal in teletext or the like, to the SP encode section **55**.

Each decode section compresses each signal into packets (in such a manner that, when each packet is divided into packs, each pack contains 2048 bytes) and input them to the formatter **56**. The respective decoder sections **53**, **54**, and **55** decide and record the PTS and DTS of each packet according to the value in the STC section **38**, as the need arises.

The formatter section **56** stores the packet data into the buffer memory section **57** temporarily and thereafter packs each of the inputted packet data items, mixes them on a GOP basis, and inputs the resulting data to the D-PRO section **36**.

The D-PRO section **36** puts together units of **16** packs into ECC groups and sends them labeled with ECC to the drive section **32**. When the drive section **32** is not ready for recording, the D-PRO section **36** transfers them to the temporary storage section **34** and waits for the drive section **32** to be ready for recording. When being ready for recording, the drive section **32** starts to record. To hold more than several minutes of recording data in high-speed accessing, the temporary storage section **34** is expected to be a large capacity memory.

At the time of recording end, the information necessary after the recording end is recorded in the playback control information **102** in the control information **78** and the volume & file management area **70** and then the video-recording operation is ended. To read and write files from and into the volume & file management area **70**, the microcomputer can read and write data from and into the D-PRO section **36** via a microcomputer bus.

In data processing during playback, when the MPU section **30** receives a playback instruction as a result of the user's key input, it reads the volume & file management area **70** via the D-PRO section **36** from the drive section **32** and decides the address to be reproduced. Here, the management area indicates a volume descriptor and a file management section. The volume descriptor is used to judge whether or not the disk is a DVD disk. The information in the file management section is used to take out the control information **78**. On the basis of the control information **78**, the video objects **82**, **84**, and **86** corresponding to the title to be reproduced are determined and the address at which playback is to be started is decided.

The MPU section **30** sends the address of the decided data to be reproduced and a read instruction to the drive section **32**. The drive section **32** reads the sector data from the disk **10** according to the sent instruction, corrects errors in the data at the D-PRO section **36**, and outputs the data in the form of packs to the decode section **60**.

In the decode section **60**, the separator **62** receives the read pack data, puts together the data into packets, and transfers them according to the type of data in such a manner

that it transfers the video packet data (MPEG video data) to the video decode section **64**, the audio packet data **68** to the audio decode section **68**, and the sub-picture packet data to the SP decode section **65**. The PTS of each of the sent packet data items is loaded into the STC section (the MPU section **30** sets the PTS in the pack in the STC **38**,. or the video decoder section **64** sets the PTS of the video data item in the STC section automatically). Thereafter, each decode section carries out the playback process in synchronization with the value of the PTS (presentation time stamp) in the packet data item (while comparing the value of the PTS with that of the STC), thereby reproducing moving pictures with titles on TV.

Furthermore, the playback operation of the microcomputer of the present invention will be explained according to the operation flow shown in FIGS. **16** and **17**. A normal playback operation will start, when the PLAY key is pressed. At this time, if the title number has not been specified beforehand, the playback of a file with title 1 corresponding to the default, that is, a video object (VOBU), is assumed to be started.

When step **S10** in FIG. **16** is started, the control information **78** is read first as shown in step **12**. Specifically, the PGC information **116** of FIG. **8** in the control information **78** is read into the MPU **30**. As shown in step **14**, when the user specifies a title, or default title **2** is selected, each piece of information on the desired title is taken in from the search pointer in the PGC information table **110** and the beginning address of the video object is taken out. Namely, the PGC number to be reproduced and the cell number are determined. As shown in step **S16**, each decoder is subjected to initial setting according to the contents written in the playback management table of the control information. As shown in step **18**, the cell to be reproduced is searched for according to the contents of the PGC I **116** and the necessary pre-processing command is executed. The pre-processing command is written in a command table provided in the PGC information table **110**, as the need arises. Thereafter, the cell is reproduced as shown in step **S20**. As shown in step **S22**, when the cell reproduced is not the last cell, the next cell number is counted up as shown in step.**S24**, and control is passed to step **S20**.

At step **S22**, the playback end of the cell is waited for. After the cell has played back, control is kept still for the still time of the cell as shown in step **S26**. When the still time is 0, control is passed without doing anything to the next step **S28**. Thereafter, a post-processing command is executed at step **S28**. Like the pre-processing command, the post-processing command is written in a command table provided in the PGC information table **110**, as the need arises, and is taken out, as the occasion demands.

When at step **S30**, the playback does not end and there is a PGC to be reproduced next, the next PGC number is determined and control is passed to step **S18**. When the playback ends, a playback end process is executed at step **S32**. That is, each decoder is reset and the GPRM is reset.

Next, the cell playback operation of the microcomputer shown in steps **S20** and **S22** of FIG. **16** will be explained according to the operation flow of FIG. **17**. When the process in reproducing a cell shown in step **S40** is started, a check is made to see if VOBUs are consecutive as shown in step **S42**. If they are consecutive, control is passed to step **S48**. In step **S42**, when the cells are not consecutive, the PGC information **116** is referred to at step **44**, the playback start address is determined, and the data read command, together with the playback start address, is set in the drive section **32**. The control information **78**, that is, the cell playback start time (C_PBTM) in the cell playback information **120** is taken in by the MPU **30** and stored in the RAM. The cell playback start time (C_PBTM) is displayed on the display unit and the playback of the cell is resumed on the basis of the playback time. As shown in step **S50**, when the stop key is pressed in the course of reproducing the cell, control is passed to step **60**, where a playback interrupt operation is started. That is, the necessary playback interrupt information is written in a playback interrupt information table prepared as a single file shown in FIG. **9**. Thereafter, the cell playback ends on the basis of the a playback stop instruction as shown in step **S62**.

When at step **S50**, the stop key is not pressed in the course of reproducing the cell, a check is made at step **52** to see if the cell corresponds to the last cell. If the cell is not the last cell, control is returned to step **S50**. If the cell is the last cell, the playback of the last VOBU in the cell is waited for as shown in step **S54**. When the playback of the last VOBU has ended, control is kept still for the still time of the cell and control is passed to the next step **S58**. When the still time is 0, control is passed without doing anything to the next step **S58**. Because the cell is the last cell at step **58**, control is passed to step **S26** in FIG. **16**.

The process in a case where, for example, the DVD disk **10** is removed after the cell playback is interrupted, and then the DVD disk **10** is loaded into the DVD recorder again to resume the playback will be explained by reference to FIG. **18**.

After the DVD disk **10** has been loaded into the DVD recorder, when the playback is resumed by pressing the resume playback key as shown in step **S70**, the playback interrupt information table of FIG. **9** is first read from the disk as shown in step **S72**. On the basis of the playback interrupt information in the playback interrupt information table, the playback title during interruption, in other words, the video object is determined. On the basis of the information, the register in each section is set. The necessary information in the information is stored again into the RAM of the MPU **30**. Thereafter, the control information **102** is read at step **S76**. Here, the PGC information **116** is stored in the RAM of the MPU **30**. As shown in step **S78**, the PGC number to be reproduced, cell number, and VOBU number are determined on the basis of the playback interrupt information in the playback interrupt information table. As shown in step **S80**, the video decoder **64**, sub-picture decoder **65**, and audio decoder **68** are set similarly on the basis of the playback interrupt information. As shown in step **S82**, a check is made to see if the address at which the playback is to be resumed is the beginning of the cell. If it is the beginning of the cell, the pre-processing command is executed as in the normal playback process at step **18**. Thereafter, control is passed to step **S90**, where the normal playback process shown in FIG. **16** is executed. Specifically, the process in cell playback is executed as in step **S20** of FIG. **16**. If the address at which the playback is to be resumed is not the beginning of the cell, the PGC information **116** is read as shown in step **S84** and the playback start address is determined. For example, the relative address of the VOBU is referred to and the relative address is added to the first VOBU address in the cell, thereby determining the playback start address. Once the playback start address has been determined, a read instruction is given to the drive section **32** using the address as shown in step **S86**. At step **S90**, the VOBU is interpreted as the first VOBU and the playback of the first VOBU is resumed as in the normal cell playback. Step **S92** to step **104** after the resumption corre-

spond to the processes from step S22 to step S34, which executes processes similar to what has been explained above. Thus, for detailed explanation, refer to step S22 to step S34 shown in FIG. 16.

Next, the process of displaying the playback remaining time using the playback interrupt information in the playback interrupt information table shown in FIG. 9 will be explained by reference to FIG. 19. The playback remaining time corresponds to the remaining time of the program in a case where a certain program is recorded on a disk or more than one program is recorded on a disk and the user interrupts the playback in the course of playing back the program, leaving part of the program unwatched, or to the playback time of the program in a case where there are some the user has not watched in the programs recorded on the disk. The programs recorded on the DVD disk are important to the user. In addition, whether the user has watched the programs, and if not, how long the remaining time is are also important to the user. In a case where the remaining time can be known disk by disk, if busy users of today can know easily whether they can watch the programs in free time, this will help provide the user a comfortable environment.

In the processing of FIG. 19, explanation will be given, provided that a cell corresponds to a program and a PGC corresponds to a recorded title. First, a DVD disk unknown as to whether it has been watched is loaded into the disk changer section 110, thereby making preparations for playback. Thereafter, as shown in step S110 of FIG. 19, when the remaining time key is pressed via the key input section (not shown), the process of displaying the playback remaining time is started. After the process is started as shown in step 111, the playback interrupt information shown in FIG. 9 is read and the cell ID whose playback has been interrupted is checked. Referring to the cell ID, the cell playback information of FIG. 13 corresponding to the cell is read. The playback time of the cell is taken out from the cell playback information and the elapsed time in the cell indicating the time during which playback has performed in the cell is take out from the playback interrupt information. The cell remaining time is calculating from both of those, or by subtracting the elapsed time in the cell from the cell playback time. Similarly, as shown in step S113, the PGC number of the interrupted PGC is checked from the playback interrupt information. The PGC general information of FIG. 12 corresponding to the PGC number is read and the PGC playback time is taken out. At the same time, the elapsed time, the total value of the playback time of the already reproduced cell constituting the PGC, is calculated using the cell playback information. The playback remaining time in the PGC is calculated from both of those, or by subtracting the elapsed time until the interruption of the playback from the PGC playback time. Thereafter, as shown in step S114, the program remaining time is displayed as the playback remaining time of the cell and the video-recording remaining time is displayed as the PGC remaining time. After the display has been acknowledged by the user, the process of displaying the playback remaining time is ended as shown in step S115, and control is returned to the playback preparing state.

In the above embodiment, a format structure as shown in FIG. 3 proposed as A new recording and reproducing standard has been explained. In additional explanation, there is the following structure according to a DVD video ROM complying with the already determined recording and reproducing standard. This structure will be explained by reference to FIGS. 20 and 21.

An RTR (Real Time Recorder) video manager 200 (RTR_VMG) shown in FIG. 20 corresponds to the control information shown in FIG. 3A. Following the RTR video manager, a video object set 80 is arranged. Its structure is the same, so its explanation will not be given.

The RTR video manager 200 (RTR_VMG) includes RTR video manager information 201 (RTR_VMGI) and other tables (1) 202. The RTR video manager information 201 (RTR_VMGI) includes a video manager information management table 203 (VMGI_MAT) for managing the RTR video manager information 201 (RTR_VMGI) and other tables (2). In the video manager information management table 203 (VMGI_MAT), a VMG identifier, management information including the end addresses of RTR_VMG and VMGI, and resume marker information (RSM_MARKI) acting as the playback interrupt information are written. As shown in FIG. 21, in the resume marker information (RSM_MARKI), the PGC number (PGCN) at which the marker point indicating the interrupt point is present, program number (PGN), and cell number (CN) are written as interrupt information, as in the table of FIG. 9. Furthermore, the relative time in the marker point cell, in other words, the elapsed time until interruption in the VBOU to which the cell belongs is written as PTM (Presentation Time Stamp) using a marker point (MRK_PT). Because most cells are generally recorded in such a manner that they coincide with VOBS, the time expressed by the marker point (MRK_PT) is such that the elapsed time until interruption in the cell is expressed in PTM (Presentation Time Stamp) form. The time when a marker point (MRK_PT) is attached is written as a marked time (MRK_TM).

In the other tables (1) and (2) 202 and 204 in FIG. 20, various types of information, including the playback control information 102, recording control information 104, editing control information 106, and reduced drawing information 108, are written at the same level or different levels of hierarchy.

In the resume marker information (RSM_MARKI) shown in FIG. 21, the address of the VOBU to be reproduced first after the interruption of playback is not written. It is, however, marked easily by preparing a time map describing the relationship between the elapsed time in the cell marked with the marker specified by a cell number and the address of the VOBU in the other tables (1). That is, the VOBU to be reproduced after interruption can be determined. Namely, in the other tables (1), an information table about moving-picture files is provided. In the table, files about moving-picture VOB information is provided. The files about moving-picture VOB information include time map information in which information on the VOBUs in the files is written in time map form. In the time map information, the playback start time and size of each VOBU are written. Therefore, referring to the marker point (MRK_PT) in the resume marker information (RSM_MARKI), the VOBU is determined from the time during the interruption of the playback. The address of the determined VOBU can be calculated by calculating the sum of the sizes of the VOBUs in the VOB reproduced before the determined VOBU. The VOBU determined by the calculated address is the VOBU to be reproduced first after the interruption of the playback.

Because in the format of FIG. 20, the resume marker information (RSM_MARKI) is written as VMGI_MAT 204 at a relatively higher level of hierarchy, the player can use the information immediately. Such a structure is, therefore, a user-friendly structure.

Industrial Applicability

As explained above, with the present invention, because the playback interrupt information has been written on a disk

serving as a video-recording and reproducing information recording medium, even if the disk is removed from the system, the playback can be resumed after the disk is installed again.

What is claimed is:

1. An information recording medium for recording and reproducing information, comprising:

a data area for storing a video object unit which comprises a video pack storing video data or an audio pack storing audio data, the video data or the audio data to be reproduced in a predetermined time period, the data area allowing the video object unit to be reproduced from the data area, the video pack or the audio pack including a packet header including presentation time stamps;

a management area including a plurality of information blocks for managing the data recorded in the data area, the management area including a recording area for storing information of a cell which refers to a presentation period of the data and program chain information which manages a sequence of cells including the cell; and

a beginning information block located in the management area and including a reproduction interruption information recording area for storing information for use in determining a position which is subsequent to a data area at which a reproducing operation is interrupted, and from which the reproducing operation is to be resumed, the reproduction interruption information recording area including areas for respectively storing a specified program chain number, information related to a specified cell, and time information for indicating a specified point of the position in the data area, the reproduction interruption information recording area being located close to an information area for storing information for a search pointer for a program chain.

2. An information recording and reproducing apparatus for a recording/reproducing disk which includes (i) a data area for storing a video object unit comprising a video pack storing video data or an audio pack storing audio data, the video data or the audio data to be reproduced in a predetermined time period, the data area allowing the video object unit to be reproduced from the data area, the video pack or the audio pack including a packet header including presentation time stamps, (ii) a management area including a plurality of information blocks each containing control information for managing the data recorded in the data area, the management area including a recording area for storing information of a cell which refers to a presentation period of the data and program chain information which manages a sequence of cells including the cell, and (iii) a beginning information block located in the management area, and including a reproduction interruption information recording area for storing information for use in determining a position which is subsequent to a data area at which a reproducing operation is interrupted, and from which the reproduction operation is to be resumed, the reproduction interruption information recording area including areas for respectively storing a specified program chain number, information related to a specified cell, and time information for indicating a specified point of the position in the data area, the reproduction interruption information recording area being located close to an information area for storing information for a search pointer for a program chain,

the information recording and reproducing apparatus comprising:

reading means for reading the data in the data area and the control information in the management area of the recording/reproducing disk;

control means for holding the control information read from the management area, and controlling reproducing means based on the control information;

decoding means for decoding and reproducing the data read from the data area; and

reproduction interruption information processing means for generating reproduction interruption information, and writing the reproduction interruption information in the recording area, when a reproduction interruption operation is performed while the reproduction means is performing reproduction.

3. An information recording and reproducing apparatus according to claim 2, wherein the reproduction interruption information processing means records a specified point of the specified cell in the reproduction interruption information recording area as the time information.

4. An information recording and reproducing apparatus according to claim 2, wherein the reproduction interruption information processing means records a presentation time related to a specified video object unit in the reproduction interruption information recording area as the time information.

5. The information recording and reproducing apparatus according to claim 2, wherein the reproduction interruption information processing means records a program number indicated by the program chain information in the reproduction interruption information recording area.

6. An information recording and reproducing method for a recording/reproducing disk which is configured to include (i) a data area for storing a video object unit which comprises a video pack storing video data or an audio pack storing audio data, the video data or the audio data to be reproduced in a predetermined time period, the data area allowing the video object unit to be reproduced from the data area, the video pack or the audio pack including a packet header including presentation time stamps, (ii) a management area including a plurality of information blocks for managing the data recorded in the data area, the management area including a recording area for storing information of a call which refers to a presentation period of the data and program chain information which manages a sequence of cells including the cell, and (iii) a beginning information block located in the management area and including a reproduction interruption information recording area for storing information for use in determining a position which is subsequent to a data area at which a reproducing operation is interrupted, and from which the reproducing operation is to be resumed, the information for use in determining the position including reproduction interruption information, and including areas for respectively storing a specified program chain number, information related to a specified cell, and time information for indicating a specified point of the position in the data area, the reproduction interruption information recording area being located close to an information area for storing information for search pointer for a program chain,

the recording and reproducing method comprising the steps of:

reproducing the video object unit; and

recording the reproduction interruption information on the recording/reproducing disk.

7. An information reproducing method for a reproducing disk which includes (i) a data area for storing a video object unit which comprises a video pack storing video data or an audio pack storing audio data, the video data or the audio data to be reproduced m a predetermined time period, the data area allowing the video object unit to be reproduced

from the data area, the video pack or the audio pack including a packet header including presentation time stamps, (ii) a management area including a plurality of information blocks for managing the data recorded in the data area, the management area including a recording area for storing information of a cell which refers to a presentation period of the data and program chain information which manages a sequence of cells including the cell, and (iii) a beginning information block in the management area including a reproduction interruption information recording area for storing information for use in determining a position which is subsequent to a data area at which a reproducing operation is interrupted, and from which the reproducing operation is to be resumed,

the reproduction interruption information recording area including areas for respectively storing a specified program chain number, information related to a specified cell, and time information for indicating a specified point of the position in the data area, the reproduction interruption information recording area being located close to an information area for storing information for searching for a program chain,

the reproducing method comprising the steps of:

reading control information in at least a part of the management area of the reproducing disk; and

reading data in at least a part of the data area.

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